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THE ABSTRACT RECEIPT DEADLINES FOR ALL MEETINGS will be strictly enforced. Unfortunately, late papers cannot be accommodated. When all talks have been scheduled for a given meeting, the attendant abstracts will be available for viewing on the AMS website through the program display for that meeting.

NOTATIONS IN THIS JOURNAL are the following:

* Indicates who will present the paper at the meeting.

SUBSCRIPTION INFORMATION

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PAPERS PRESENTED AT MEETINGS

THIS CALENDAR lists meetings of the Society which have been approved by the Council at which papers may be presented. Programs of Annual Meetings appear in the *Notices* and on the AMS website; programs for sectional meetings appear on the AMS Web pages in the Meetings & Conferences section, and are electronically archived in the *Notices* section on the AMS website.

MEETING #	DATE	PLACE	ABSTRACT DEADLINE	ABSTRACT ISSUE
1086	January 9–12, 2013	San Diego, CA	EXPIRED	Vol 34, No. 1
1087	March 1–3, 2013	Oxford, MS	December 4	Vol 34, No. 2
1088	April 6–7, 2013	Chestnut Hill, MA	February 12	Vol 34, No. 2
1089	April 13–14, 2013	Boulder, CO	February 19	Vol 34, No. 2
1090	April 27–28, 2013	Ames, IA	March 5	Vol 34, No. 2
1091	June 27–30, 2013	Alba Iulia, Romania	TBA	None
1092	October 5–6, 2013	Louisville, KY	August 13	Vol 34, No. 3
1093	October 12–13, 2013	Philadelphia, PA	August 20	Vol 34, No. 3
1094	October 18–20, 2013	St. Louis, MO	August 27	Vol 34, No. 4
1095	November 2–3, 2013	Riverside, CA	September 10	Vol 34, No. 4
1096	January 15–18, 2014	Baltimore, MD	TBA	Vol 35, No. 1

SAN DIEGO, CA, January 9–12, 2013

Abstracts of the 1086th Meeting.

00 ► General

1086-00-60 **Gizem Karaali*** (gizem.karaali@pomona.edu), Department of Mathematics, Pomona College, 610 North College Avenue, Claremont, CA 91711. *The Brave New World of Open Access and Creative Commons: A Humanistic Experiment in Mathematical Publishing.*

In January 2011 *The Journal of Humanistic Mathematics* (JHM) published its first issue. JHM (<http://scholarship.claremont.edu/jhm>) is an online-only, peer-reviewed, open-access journal which has passed the all-important ten-thousand-download barrier in its first anniversary. In order to remain faithful to the fundamental principles of open access, JHM uses *Creative Commons* licensing, where authors retain copyright of their work, but others are free to reuse them (with proper attribution). In this presentation Gizem Karaali, one of the founding editors of JHM, will share some experiences with open access and *Creative Commons*. (Received June 25, 2012)

1086-00-199 **Dalton Allan*** (alland@mit.edu), 5402 Nakoma Drive, Midland, MI 48640, and **Linda M. Dunklee** and **Sofya Vorotnikova**. *Variations of Cops and Robber on Graphs.*

We consider the variation of the game of Cops and Robber when there are fewer cops than the cop number of the graph. However, cops are allowed to use two kinds of devices - traps and doors. Devices are placed on vertices and prevent the robber from entering them. Traps can be moved around the graph and doors are stationary. In this presentation we present general results on the number and placement of doors and discuss the usage of devices on different classes of graphs and specific graphs. (Received August 06, 2012)

1086-00-342 **Greg Kuperberg*** (greg@math.ucdavis.edu). *My proposal for a zero-fee replacement for traditional mathematical journals.*

Research publication in physics and mathematics is in a stable but strange holding pattern. On the one hand, an increasing fraction of all research papers are posted to the arXiv. On the other hand, most papers are separately submitted to traditional journals, even if they are in the arXiv. Many journals are owned by controversial publishers; moreover, I think that the entire journal system is ripe for reform. Nonetheless the journal system is oddly stable, despite the upheavals of the Internet.

Most reform attempts are new journals with either budget subscriptions, or page charges for authors. I conjecture that these strategies can't work. Instead, I propose a zero-fee peer review system in which (a) authors

still get the publication credit that they need, but (b) the main labor costs are avoided entirely or (hopefully) greatly reduced. If the system is credible, then it might be sustainable with grants and volunteer service. Actually, I proposed this model about 10 years ago, but I never tried to implement it. I will give an updated discussion. (Received August 22, 2012)

1086-00-351 **Clement B Ampadu*** (drampadu@hotmail.com), 31 Carrolton Road, Boston, MA 02132.
Return Probability of the Fibonacci Quantum Walk.

In this paper the return probability of the one-dimensional discrete-time quantum walk is studied. We derive probabilistic formulas for the return probability related to the quantum walk governed by the Fibonacci coin.

Return Probability of the Fibonacci Quantum Walk. Communications in Theoretical Physics (2012), Volume 58, Number 2, pp 220-224 (Received August 23, 2012)

1086-00-389 **Klaus Kaiser*** (klaus@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204-3008. *"Author-Sponsored-Journals", a practical variation of the "Open-Access" business model.*

In the Open Access business model, authors are responsible for all costs of journal production. In return, the publisher makes all journal content freely available and authors barely face any copyright restrictions. There are many reasons why for subscription based journals, the number of paid subscriptions has been stagnant or even declining. Most well known mathematics journals appear in print as well as in electronic format, and costs related to printing have been steadily increasing. For the publisher there is always the option to increase subscription rates in order to make up for insufficient revenues. However, non-profit journals can also ask in good conscience for voluntary contributions, in form of page charges or donations. During the past years, the Houston Journal of Mathematics has made a serious effort to get authors involved to honor our request for voluntary page charges, or at least make sure that the library subscribes to our journal. In my talk I will discuss the overall success rate of this kind of a direct approach, but also mention opposing views expressed by some authors. I will also bring up some other topics related to the business of journal production. (Received August 28, 2012)

1086-00-396 **Henry Krell*** (henry.krell@springer.com), 233 Spring Street, New York, NY 10013.
Making Content Reflowable for the Reading Device.

For over 400 years the publishing process provided content to only one reading device, the printed paper page. In the last 25 years with the introduction of personal computing and later the internet, publishing has been challenged with providing content to a constant development of new reading devices: the computer, the smart phone, and the tablet. Whereas the characteristics of the printed book page remained relatively constant for centuries, these new electronic devices with their specific qualities have been introduced in relatively short time periods. Further these devices have become an essential part of everyday life across most cultures in the world. While publishing developed the PDF as a bridge from the paper page to the electronic screen, this, in hindsight, was just transferring printed matter to a digital medium. It did not incorporate the attributes of the electronic devices which would enhance the reading and learning experience. We highlight the challenges and the solutions publishing has had to make so that content is not only reflowable for the reading device but also discoverable in an age where information is unlimited. (Received August 29, 2012)

1086-00-790 **Ashley Klahr*** (aklahr@sandiego.edu), **Elaina Aceves** and **David Heywood**.
Embedding Cycles and Bipartite Graphs in $PG(n, q)$. Preliminary report.

Our work builds from that of Lazebnik, Mellinger, and Vega about the embedding of graphs in finite projective planes. First, we expand on their findings on embedding cycles in $PG(2, q)$ by taking cycles in 2 dimensions and piecing them together to get a cycle in three dimensions. Then similarly we piece together cycles in $n - 1$ dimensions to get a cycle in n dimensions. Additionally, we expand their findings on embedding bipartite graphs in $PG(2, q)$ by looking at bounds for complete bipartite graphs that can be embedded in $PG(3, q)$. (Received September 12, 2012)

1086-00-997 **Gert-Martin W. Greuel*** (greuel@zentralblatt-math.org). *Changes and enhancements of the publication structure in mathematics.* Preliminary report.

My talk will focus on three aspects of Electronic Publishing:

- Cross-linking of publications, software and research data in mathematics
- Selection and quality control in indexing mathematical publications
- Changes of the publication structure in mathematics

The statements and conclusions will be mainly based on experiences with Zentralblatt MATH (zbMATH). (Received September 17, 2012)

1086-00-1003 **Rob Kirby*** (kirby@math.berkeley.edu), Mathematics Department, University of California, Berkeley, CA 94720-3840. *Remarks on the economics of math journal publishing.* I will expand on the contents of my Scripta Manent article in the October 2012 Notices and discuss new ventures including the open access journals, Forum of Mathematics, Pi/Sigma. (Received September 17, 2012)

1086-00-1008 **Holly E Attenborough*** (heattenb@indiana.edu), Bloomington, IN 47401. *A Decomposition for Idempotents of the Brauer Monoid.* Let $G = \text{Gal}(K/F)$ for a Galois field extension K/F . The Brauer Monoid, $M^2(G, K)$ is defined by adapting the cocycle construction of the Relative Brauer Group, $Br(K/F) = H^2(G, K^*)$. We adapt the cocycles by allowing the image to be all of K , these cocycles, $f : G \times G \rightarrow K$, are called **weak** 2-cocycles. Let e an idempotent weak 2-cocycle, define the group $M_e^2(G, K)$ to be $\{[f] \in M^2(G, K) | ef = f\}$. For a specific ring R_e associated with an idempotent e , we have a complex on R_e -modules, M^e , that gives us that $M_e^2(G, K) \cong H^2(\text{Hom}_{R_e}(M^e, K^*))$. The idempotents e are in one-to-one correspondence with lower subtractive partial orders on the group G , $e \mapsto \leq_e$. For S and T lower subtractive subsets of G , such that $S \cup T = (G, \leq_e)$, there exists a split short exact sequence on the complexes:

$$0 \rightarrow M^{S \cap T} \rightarrow M^S \oplus M^T \rightarrow M^e \rightarrow 0.$$

This gives us a long exact sequence on cohomology, which can aid with the computation of $H^2(\text{Hom}_{R_e}(M^e, K^*)) \cong M_e^2(G, K)$. (Received September 17, 2012)

1086-00-1036 **Walter D Neumann*** (neumann@math.columbia.edu), Mathematics Department, Columbia University, 2990 Broadway, MC4424, New York, NY 10027. *Lessons learned from G&T and MSP.*

The journal "Geometry & Topology" received its first submissions in 1996 and rapidly became the leading journal in its field, leading to the creation a decade later of the not-for-profit publishing house "Mathematical Sciences Publishers" and the birth several other journals. I will describe the history and lessons learned along the way. (Received September 18, 2012)

1086-00-1162 **Vindra Dass*** (vindra.dass@springer.com). *SpringerOpen: Springer's open access platform.*

In our endeavor to best serve the scientific community, STM Publishers have adapted to a perpetual state of evolution and growth, ranging from the methodical, but dramatic shift from traditional print product into the dynamic electronic platform, to now the most contemporary wave of transformation: open access. Springer has recognized and is strongly answering the call from academia to offer an alternative platform, which utilizes emerging technological advances, while providing a much-desired alternative publishing model. SpringerOpen has decidedly adopted methods, techniques, and approaches that have been pioneered by our BioMed Central colleagues, such as multiple membership models, which allow for great flexibility. Springer' global reach coupled with BioMed Central's expertise, techniques, and structure, promises to make SpringerOpen an alternative publishing platform that will provide our authors and editors with an Open Access option that truly delivers ease-of-use, value for money and maximum visibility for their published research. As the SpringerOpen portfolio continues to mature, we are keen understanding the needs of our researchers, which often results in specialized perks, such as MathJax. (Received September 19, 2012)

1086-00-1279 **Joseph M. DiMuro*** (joseph.dimuro@biola.edu). *On p-adic Sums of Games.* Preliminary report.

The theory of impartial games is well known. Given an impartial game G , we may associate to it its Grundy number $\mathcal{G}(G)$, the smallest ordinal which does not appear among the Grundy numbers of G 's options. The impartial games which are losses for the next player to move are then exactly the impartial games with Grundy number 0. To find the Grundy number of a sum of multiple games (where a player's turn consists of a move in exactly one of the component games), one may write the Grundy numbers of each component game in base 2, and then add without carry.

Making use of a new mechanic called a "challenge", we will define the " p -adic" sum of impartial games for every prime p , where the Grundy numbers of each component game should be written in base p and summed without carry. We will then present the winning strategies for a variety of impartial games played under the p -adic sum. (Received September 20, 2012)

- 1086-00-1315 **Thomas M. Smith*** (tom.smith@noaa.gov), 5825 University Research CT, Suite 4001, College Park, MD 20740, and **Samuel Shen, Phillip Arkin and Li Ren.** *Precipitation Reconstructions from Historical and Modern Data.*

Statistics from recent satellite-based precipitation analyses are used with historical data to reconstruct monthly precipitation anomalies beginning 1900. Statistics include spatial covariance and correlations with other variables. Historical data used include gauge data over land and some islands, and historical analyses of sea-surface temperature and sea-level pressure which are correlated with precipitation on long time scales. Reconstructions are particularly important for analysis of oceanic variations where there are no direct historical measurements. Large-scale long-term changes in the ocean-area reconstructions are qualitatively consistent with changes in physically-based coupled climate models that include changes in greenhouse gases and aerosols, indicating increasing global precipitation over the 20th Century. Error estimates for the reconstructions indicate that global changes over the 20th Century are slightly larger than the uncertainty. (Received September 21, 2012)

- 1086-00-1321 **Johan Rudnick*** (director@cms.math.ca), Suite 209, 1725 St. Laurent Boulevard, Ottawa, Ontario K1M 1Y1. [Draft] *Math Journal Epitaph.*

Beloved producer of printed issues. Cherished distributor of volumes. Valiant defender of controls.

Succumbed to open access at the ripe old age of two hundred and some odd years.

Publishing the research is dead; long live research. (Received September 21, 2012)

- 1086-00-1388 **Louis Bohorquez*** (ljbohorquez@gmail.com), 12640 Redberry St, El Monte, CA 91732, and **Jason Xu** (jasonxu90@gmail.com), 5637C Brooklyn Ave NE, Seattle, WA 98105. *Regional Coverage with Steerable Satellite Sensors.*

We consider the problem of calculating visibility periods during which a steerable satellite sensor can capture a set of target points on the earth. Precisely locating these periods requires calculating the optimal pointing direction at any given point in the satellite orbit. We reduce this problem to a minimax optimization problem, and discuss two solutions, detailing an iterative algorithm as well as a precise mathematical solution. Results to the steerable sensor problem are an improvement over previous fixed sensor capabilities. Finally, we recommend ideas for future research directions toward improving these algorithms. (Received September 21, 2012)

- 1086-00-1672 **Anna-Rose G Wolff*** (awolff2@gnu.edu). *Support Vector Machines and the Exterior Point Method.*

Support Vector Machine (SVM) learns an unknown function by recognizing underlying patterns within large data sets. One of the goals of the SVM is to find the support vectors, or data points that contain the most important information about the unknown function. We develop an optimization algorithm for finding the support vectors based on an exterior-point method and data decomposition. (Received September 24, 2012)

- 1086-00-1929 **Eric Van Buren*** (eric.vanburen@asu.edu), **James Upton** (jtupton@asu.edu), **Scott Van Buren** (scott.vanburen@asu.edu) and **Mohamed Moustaoi** (mohamed.moustaoi@asu.edu). *A New High-Order Filter for Leapfrog Time Integration of Wave Problems.*

Asselin-filtered leapfrog time integration is the standard numerical scheme used in climate and atmospheric modeling due to its favorable computational efficiency, stability, and ability to reduce leapfrog's non-physical computational modes. However, the Asselin filter has a key disadvantage—significant damping of the physical computational modes which results in numerical degradation of the solution. We present a high-order filter that is superior to and more robust than the Asselin filter. In particular, the high-order filter increases the accuracy of the solution to third order in amplitude and decreases the damping of the physical computational modes, while still damping the non-physical computational modes. This talk will provide both a theoretical background and numerical analysis of the high-order filter, and an example comparing the high-order filter to a Runge-Kutta scheme. (Received September 24, 2012)

- 1086-00-1981 **Emmanuel Daring** (emmanuel.h.daring@williams.edu), **Casey Douglas** (cjdouglas@smcm.edu), **Isabel Guadarrama** (iguadarram@brynmawr.edu), **Samantha Sprague** (samantha.sprague1@marist.edu) and **Carrie Winterer*** (cgwinterer@smcm.edu). *What Do Math and LEGOs Have in Common?*

Standard optimization strategies combined with discrete mathematics and number theory allow us to show that the smallest number of unit squares needed to enclose A units of area is

$$P(A) = 2 \left\lceil 2\sqrt{A} \right\rceil + 4.$$

This question lends itself to interesting generalizations that include using different brick-shapes, imposing various weighting constraints, and the formulation of a "LEGOTM double bubble" problem comparable to the one solved by Dr. Frank Morgan. (Received September 24, 2012)

1086-00-2008 **Thomas E Leathrum*** (leathrum@jsu.edu). *Emerging Standards in Electronic Math Publishing.*

This presentation will look, based on the author's experiences as Editor of the MAA online journal *Loci*, at the possibility that new standards such as Epub3 and technologies such as MathJax may provide a better approach for electronic journal publication. In a publication model based on these standards and technologies, authors could, for example, submit articles as packaged complete Epub3 documents containing various forms of supported content such as MathML, HTML5 embedded media, and SVG graphics made interactive through JavaScript scripting. The journal's server could then offer its readers individual published articles or dynamically repackaged multiple article sets as downloadable Epub3 documents. Among other differences from current online publication models, this approach allows electronic but largely offline and mobile reading of interactive math content. (Received September 24, 2012)

1086-00-2022 **Delaram Kahrobaei*** (dkahrobaei@gc.cuny.edu), 365 Fifth Ave, New York, NY 10016, and **Maggie Habeeb** and **Vladimir Shpilrain**. *A Secret Sharing Scheme Based on Group Presentations and the Word Problem.*

A (t, n) -threshold secret sharing scheme is a method to distribute a secret among n participants in such a way that any t participants can recover the secret, but no $t - 1$ participants can. In this talk, we propose two secret sharing schemes using non-abelian groups. One scheme is the special case where all the participants must get together to recover the secret. The other one is a (t, n) -threshold scheme that is a combination of Shamir's scheme and the group-theoretic scheme proposed in this talk. This is a joint work with M.Habeeb and V.Shpilrain. (Received September 24, 2012)

1086-00-2129 **Randy S. Kiefer*** (randy.kiefer@clockss.org). *Challenges in digital preservation – local choice / global concerns.*

A focus on digital preservation issues: I. Quick overview of the goals of preservation II. Journals vs. ebooks vs. databases vs. supplementary materials: (a) What is important and necessary for each? (b) Do formats matter? (c) The devil in the details regarding rights. III. Local concerns and global concerns: (a) Rationale for local efforts. (b) Necessity of global solutions (Received September 24, 2012)

1086-00-2238 **Jason Grout*** (jason.grout@drake.edu), **Ira Hanson**, **Alex Kramer**, **Steven Johnson** and **Byron Varberg**. *The Sage Cell Server: embedding live computations in web pages.*

Sage (<http://sagemath.org>) is a comprehensive free open-source mathematics software system. We will present our work on the Sage Cell Server (<http://aleph.sagemath.org>), which enables anyone to embed live Sage computations directly into any web page. These computations can easily include 2d and 3d plots, sliders, buttons, and other controls to interact with the computation. You can also use permalinks and QR codes to link to computations from paper textbooks and emails. We will present a number of places these embedded interactive computations are being used, including textbooks, personal webpages, wikis, and a new online database of short Sage examples at <http://interact.sagemath.org>. We will also show you how you can easily embed interactive computations in your web page with just a few lines of javascript and HTML. (Received September 25, 2012)

1086-00-2384 **Ravi Chinta**, **MB Rao**, **Vivek Narendran**, **Ganesh Malla** and **Hem Joshi***, joshi@xavier.edu. *Economic Recession and Headache Related Hospital Admissions.*

We want to evaluate the incidence of headaches across different regions of the United States before and during an economic recession and assess its relationship to national unemployment rates. Years 2008 and 2009 were determined as 'peak recession' and headache related admissions, particularly the uncomplicated headache increased significantly during recession when compared to the prerecession period. Age group 25-54 years was similarly more affected during recession. The hospital revenues increased even though the length of stay and average cost of stay decreased. These findings are consistent with our understanding of effects of stress and unemployment on psychological and physical health. (Received September 25, 2012)

1086-00-2439 **Emily A Wickstrom*** (eaw4@williams.edu), 3156 Paresky Center, Williamstown, MA 01267, and **Shelby Heinecke** and **Cesar E Silva** (cesar.e.silva@williams.edu), Williams College, Williamstown, MA 01267. *Measure-Theoretic Sensitivity.*

Recently, the topological notion of sensitivity has been studied in the measure-theoretic setting and many types of measure-theoretical sensitivity have been proposed. We present connections between new and pre-existing measure-theoretic notions of sensitivity in the setting of nonsingular and measure-preserving \mathbb{N}^d -actions. (Received September 26, 2012)

1086-00-2541 **F. Bonizzoni***, francesca.bonizzoni@epfl.ch, and **F. Nobile** and **A. Buffa**. *Equations for the probabilistic moments of the solution of the stochastic Hodge Laplacian.*

Many natural phenomena and engineering applications are affected by uncertainty in the input data since the data are either incompletely known or contain a certain level of variability. One way to overcome this is to describe the problem data as random variables or random fields, so that the determinist problem turns into a stochastic differential equation (SPDE).

The solution of a SPDE is itself a random field $u(\omega)$ with values in a suitable function space V . The description of this random field requires the knowledge of its m -points correlation $\mathcal{M}^m[u] \in V^{\otimes m}$. An alternative technique to Monte Carlo Method is to derive the moment equations, that is the deterministic equations solved by the probabilistic moments of the stochastic solution. These can be written exactly in the case of a linear problem and stochastic forcing terms.

Given complete statistical information on the random input data, the aim of our work is to compute the statistics of the solution. We take into account the mixed formulation of the Hodge Laplacian with stochastic loading terms. We derive and analyze the moment equations. We find stable tensor product finite element discretizations, both full and sparse, and provide optimal order of convergence estimates. (Received September 25, 2012)

1086-00-2575 **Rachel E Sefton*** (reb2c@mtmail.mtsu.edu). *Effects of Writing before Tests in College Algebra.* Preliminary report.

Past research has found a negative correlation between test anxiety and test performance. In 2011, Gerardo Ramirez and Sian L. Beilock found that highly test anxious 9th grade Biology students who wrote about their feelings about their impending final exam performed better on the exam than those who wrote about something else; students with low test anxiety were not affected by the intervention. The current research examines whether a College Algebra class writing about feelings before unit tests outperforms another College Algebra class writing about something else and whether any effect changes over the course of the semester. (Received September 25, 2012)

1086-00-2647 **Elaine T Spiller*** (elaine.spiller@marquette.edu) and **D W Han**. *Data assimilation and model error for an idealized 3D ocean eddy.*

A simple kinematic model of a wind-forced three dimensional ocean eddy can illuminate complex dynamics of the fluid flow. However, a kinematic model alone cannot hope to perfectly describe reality or the data one may collect. As such we propose modeling the difference between the kinematic model and data as a random function which we refer to as a bias. Once the random function is fit, we use the now bias-corrected kinematic model to explore the eddy dynamics. (Received September 25, 2012)

1086-00-2694 **Stefaan Dirk Delcroix*** (sdelcroix@csufresno.edu). *The Hausdorff dimension of a graph-directed set whose underlying multigraph is a Cartesian product or a tensor product of multigraphs.*

We can associate a graph-directed set K and a weighted incidence matrix A with a given strongly connected, directed multigraph G , a sequence of subsets of \mathbb{R}^d and a sequence of contraction similarities. For $s \geq 0$, we put $A(s) = (a_{i,j}^s)$. Let $\rho(s)$ be the spectral radius of $A(s)$. Then the Hausdorff dimension of K is the unique solution to $\rho(s) = 1$.

We use the above result to compute the Hausdorff dimension of graph-directed sets when G is either the direct product or the tensor product of a finite collection of strongly connected directed multigraphs. We give explicit formulas in terms of the eigenvalues of the graph and the similarity ratios used with each graph. (Received September 25, 2012)

1086-00-2869 **Ryan A. Anderson*** (rander43@students.kennesaw.edu), 2590 Mountain Brook Road, Canton, GA 30114. *Simultaneous Approximation of a Function and Its Derivative by Linear Splines.*

Linear splines, in particular interpolating splines, are used to approximate a function given on a discrete set of values of the function. Linear splines are widely used in many applications targeting geometric modeling of curves and surfaces as piecewise linear functions are generally easy to work with. The concept of linear splines have been extended to bilinear (linear in each variable) and further to polylinear splines with many results having been proved. In this talk, I will introduce the concept of spline interpolation and discuss new results on simultaneous approximation of a multivariate function (of certain smoothness) and its derivatives by linear splines as well as present some results on the error of approximation. The work was done under the supervision of Dr. Yuliya Babenko. (Received September 25, 2012)

1086-00-2878 **Douglas B Meade*** (meade@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208, and **Philip B Yasskin** (yasskin@math.tamu.edu), Department of Mathematics, Texas A&M University, 3368 TAMU, College Station, TX 77843-3368. *MathLex: A Tool for Presenting and Doing Mathematics on the Web.*

Donald Knuth introduced T_EX to the mathematics community in the Gibbs Lecture at the 1978 Joint Mathematics Meetings. This was a pivotal event in the development of the impressive and ever-expanding collection of tools that continue to transform all manners of mathematics communication.

Today's mathematicians are increasingly interested in preparing materials that can be accessed in a variety of electronic formats (HTML, PDF, CDF, ePub3, ...), on a wide array of devices (computers, tablets, pads, e-readers, smartphones, ...). Current tools for creating mathematical materials on the web include HTML5, javascript, MathJax, JSXGraph, jQuery, These tools are more powerful and generally easier to use than many of their predecessors.

In addition to presenting mathematics on the web we also want to “do” mathematics on the web. This requires the ability to create mathematical expressions that both retain their mathematical meaning and are professionally typeset. Towards this end the presenters introduce MathLex, an open source mathematics parser and renderer written in JavaScript.

This talk provides the background necessary to better appreciate the other talks in this session. (Received September 25, 2012)

1086-00-2995 **Dorin Comaniciu***, Imaging and Computer Vision, Siemens Corporate Technology, Princeton, NJ. *Towards Personalized Medicine* Preliminary report.

The promise of personalized medicine is to do more in advance, promote early detection of the disease, more efficient workflows, and provide patient-specific therapies. This talk will analyze three emerging dimensions of imaging for personalized medicine: knowledge-based imaging, real-time, and in-silico modeling of the body function and disease. We will underline the role that mathematical sciences play in parsing the medical image data into hundreds of quantifiable components. We will showcase comprehensive cardiac models that include patient's anatomy, dynamics, hemodynamics and biomechanics. By presenting example applications that make today a difference in hospitals we will extrapolate on the imaging technology potential, expectations for the near future, and the increased demand for applied mathematics. (Received October 01, 2012)

01 ► History and biography

1086-01-148 **Mohammadreza Shahidipak*** (msnoor100@yahoo.com), , Iran. *Final period of Mathematic in the west of Islamic world in Medieval.*

In the history of science, the role of Muslims in arithmetic, mathematical geography, geometry, applied mathematics and speeding up calculations, creating new relations, equations and symbols and solving new problems was not only as a bridge to transfer mathematic to Europe. The present article has shown that Islamic west mathematicians reached mathematics to its final stage of development before Newton and Pascal. The works of some individuals like, Qalsādī, and Marākishī provide clear proof for this theory in mathematic history, which has been studied in this article. Among them, the book Dawāt Al-Asmā of Qalsādī by creating many symbols like the letter (چ) as a radical for the root of last stage of mathematic development in the rules of root taking and the book Jāmī Al-Mabādī wa Al-Ghāyāt of Marākishī on mathematical geography are considered as the most important works through east to west of the world, and as the final stage of development in mathematical geography. A part of the doctoral thesis of the author deals with this theory.

Key words: Mathematics, Qalasadi, Hafisids Kingdom (Received July 28, 2012)

- 1086-01-173 **Andrea Arredondo*** (andrea.aat@gmail.com), Mexico City, Mexico. *Why Natural Numbers Are Called Natural: The Impact of Social Context in Nineteenth-Century Mathematics*. Preliminary report.

Natural numbers have been the main subject of a great variety of studies. However, the reason why they were called natural numbers has received little attention. In order to understand how natural numbers became natural, it is necessary to look back at the nineteenth-century German states. It is within this background that the term natural number appears for the first time in the works of Carl Friedrich Gauss, Hermann von Helmholtz, Leopold Kronecker, Gottlob Frege, and Richard Dedekind. But why did they refer to natural numbers in that way? My aim is to show that the naturality of natural numbers is not merely a result of mathematical insights, but that it is possible to see it as the product of a mixture of political, academic, and cultural forces. Transformations in education and a renewed humanism in the German states of the nineteenth-century shaped the way in which knowledge was pursued. Accordingly, certain visions of how and what was studied were privileged. German mathematicians did not escape from the influence of those visions. Ultimately, they were directed towards a specific conception of logic which not only served as a foundation for natural numbers, but made of them a natural consequence of the human mind. (Received September 21, 2012)

- 1086-01-336 **Melissa Davidson***, mdavids4@nd.edu. *The Wave Stands Alone: Journey of a Solitary Wave*.

Solitary waves, or solitons, are a popular subject in partial differential equations. They evoke many questions, including where did they come from? Who thought that was worth studying? We shall trace the history of the solitary wave starting from the very beginnings of general wave theory and ending with some discoveries about solitary waves themselves. (Received August 22, 2012)

- 1086-01-457 **William Dunham*** (wdunham@muhlenberg.edu), Department of Mathematics and CS, Muhlenberg College, Allentown, PA 18104. *Your humble Servant, Is. Newton*.

Half a century ago, Cambridge University Press began publishing the letters of Isaac Newton. Last summer, I read them all. In this talk, I share my favorite examples of Newton as correspondent. From his first known letter (where he scolded a friend for being drunk), through exchanges with Leibniz, Locke, et. al., and up to documents from the period when he ran the Mint in London, these writings give glimpses of Newton at his best ... and worst. I'll end with Newton's most-quoted line and how my search for the original led me, improbably, to a smallish library in Philadelphia.

Parental Advisory: This talk contains no mathematics. (Received September 03, 2012)

- 1086-01-461 **Victor J Katz*** (vkatz@udc.edu). *Algebra in Words vs. Algebra in Symbols*. Preliminary report.

Is it an “algebra problem” if both the statement and the solution are given entirely in words? This question has been debated by historians studying the development of algebra and trying to decide on its origins. If symbolism is an essential facet of algebra, as some historians claim and as we normally teach algebra today, then it cannot be said to have begun much earlier than the beginning of the seventeenth century. So did Islamic mathematicians beginning in the ninth century actually do algebra, given that their work was entirely verbal? We will consider some aspects of the history of solving problems for unknown values in medieval Islam and in late medieval Europe and try to develop some reasonable answers to the above questions. In addition, we will look at the difficulties that “algebra in words” presented to Islamic mathematicians and raise the question as to whether the lack of symbolism in Islamic mathematics was in part responsible for its failure to develop further than it did. (Received September 03, 2012)

- 1086-01-473 **Sloan E Despeaux*** (despeaux@wcu.edu), Dept. of Math and CS, Western Carolina University, 424 Stillwell, Cullowhee, NC 28723. *Mathematical questions: A convergence of practices in British mathematical journals, 1795-1901*.

The persistence and wide-ranging popularity of the “questions and answers” format in British mathematical journals from 1795 to 1901 can be viewed as a convergence of two different mathematical practices: (1) the recreational problem-solving tradition supported by the almanacs of the 18th century, and (2) the problem-solving tendencies and tastes of Cambridge graduates and the students of these graduates. These tendencies and tastes were encouraged through the conversion of the Cambridge Tripos to a paper-based examination at the turn of the 19th century and the subsequent diffusion of paper-based examinations throughout Britain during the second half of the 19th century. This paper will trace the “questions and answers” format from 1795, when Thomas Leybourne began his *Mathematical and Philosophical Repository*, to 1901, when the first series of the *Mathematical Questions ... from the “Educational Times”* ended. The convergence of these two practices

resulted in the persistence of a particular method for mathematical communication and discovery that resisted the stratifying forces of professionalization. (Received September 04, 2012)

1086-01-482 **Marjorie Senechal*** (senechal@smith.edu). *Biogeometry, 1941.*

Twelve years before the discovery of the double helix, Smith, Amherst, and Mount Holyoke Colleges made a joint appointment – their first – to jump-start a brand new field. The field was “molecular biology,” a phrase then-recently coined; the appointee was a controversial British mathematician, Dorothy Wrinch. Why a mathematician, and what was the controversy? I will show how the course she gave illuminates a fierce debate over the roles of geometry and symmetry in the biological sciences. (Received September 04, 2012)

1086-01-637 **Jared E Antrobus*** (antrobusj1@nku.edu). *Mamba vs JN-25.* Preliminary report.

During World War II, US Navy mathematician/codebreakers designed a codebreaking machine called Mamba to attack the Japanese naval cipher JN-25. Mamba was used to align recovered additives with captured messages. We will discuss the mathematical ideas behind Mamba and describe how patterns in JN-25 permitted US Navy codebreakers to break JN-25 messages. (Received September 10, 2012)

1086-01-653 **Rolf Nossun*** (rolf.nossun@uia.no), Department of Mathematics, University of Agder, P.O. Box 422, N-4604 Kristiansand, Norway. *Von Mises and the Mathematical Theory of Plastic Deformation.*

Von Mises and the Mathematical Theory of Plastic Deformation.

Drawing on Cauchy’s formulation of stress in solids and Mohr’s graphical representation of primary stresses, Richard von Mises gave yield criteria for plastic deformation of isotropic and crystalline materials in two articles published in 1913 and 1928. We review these papers, trace the influence on von Mises’ work by Maxwell and Hopf, and compare with the parallel efforts of Hencky and others. Finally we present some other yield criteria in common use.

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1086-01-656 **Christophe Eckes*** (eckes@math.univ-lyon1.fr), 19, rue Denfert-Rochereau, 90000 Belfort, France. *Weyl’s lecture courses on group theory at the Institute for Advanced Study (Princeton) before the Second World War.*

In this talk, we aim at analyzing Weyl’s lecture courses on the theory of Lie groups (1934-1935) and on invariant theory (1935-1937) at the IAS. In particular, his lectures on invariant theory will lead to his famous book entitled The classical groups, their Invariants and Representations (first edition 1939, second edition 1946). To this end, we will comment two kinds of documents which can be found at the Weyl-archive (ETH-Bibliothek): 1. a series of notebooks, in which Weyl sketches the main outlines of his courses; 2. the typescript fascicules of these lectures written by Weyl with the help of his assistants: R. Brauer, O. Blumenthal and A. Clifford. We will try to determine the audience of his courses and we will describe Weyl’s situation at the Institute for the Advanced Study before the Second World War. (Received September 10, 2012)

1086-01-747 **V. Frederick Rickey*** (fred.rickey@me.com), 11 Stately Oaks, Cornwall, NY 12518, and **Theodore J. Crackel**. *What mathematics did George Washington know before he became a professional surveyor and how did he use it?* Preliminary report.

Between the ages of 13 and 15, George Washington compiled two cyphering books consisting of 180 manuscript pages. Whether he learned mathematics from tutors, from teachers, from his half-brother Austin, or on his own from various books, we do know that he mastered a good deal of arithmetic, geometry, logarithms, trigonometry, surveying and other material. We will describe in detail what he learned and show how he used it — or did not use it — in the youthful surveys in his cyphering books. (Received September 11, 2012)

1086-01-826 **Barnabas B Hughes*** (barnabashughes@hotmail.com). *Riches from the Middle Ages.*

An immobile circular slide rule from the Jewish quarter, the challenge for truth from the Moslem stance, beginning to compute with signed numbers from a European Christian: these vignettes will be shared enriched with another four or five from a treasury of medieval mathematics (800 - 1470), including the finite birth of infinite series. (Received September 14, 2012)

1086-01-886 **William Thomas Archibald*** (tarchi@sfu.ca). *Mathematical Publication in Early Nineteenth-Century Germany: Venues, Careers and Publics*. Preliminary report.

This paper is devoted to the following question; if one wanted to publish a mathematical article in Germany in the nineteenth century prior to Crelle's journal, what would one do?

I will first to consider the question of mathematical production and its purposes more generally at this period. The context in the period before, during and following the Napoleonic wars is particularly important. This was particularly the case for those who worked with mathematics in its various forms, for the key roles of mathematics in geodesy and navigation had made it the premier and foundational military art, useful also in all forms of construction and industry.

In the paper we take a look at where, how, and why mathematical work was published, considering careers to remind ourselves of their heterogeneous character, to identify publics and motivations for reaching them, and to be able at least to reflect, if without much actual data, on the economics of publishing mathematical works. (Received September 14, 2012)

1086-01-919 **Janet Heine Barnett*** (janet.barnett@colostate-pueblo.edu). *Mathematics is a Plural Noun: The Case of Oliver Byrne, Esq.*

Histories of mathematics often focus on major names and developments, as these appear from the perspective of academic mathematics in the historian's own time. Ignored are the 'lesser' practitioners of mathematics who worked alongside the better known names. Yet the activities of lesser lights can reveal aspects of the history of mathematics otherwise hidden from view. This talk casts a spotlight on one such figure: the elusive Oliver Byrne, Esq. (c1810-1875).

A self-educated engineer, self-proclaimed mathematician and prolific technical author of Irish heritage, Byrne is most remembered for his beautiful 1847 'Euclid by Colour.' His other publications suggest Byrne himself would rate his contributions to computational practice to be of even greater merit. He took particular pride in his 'Dual Arithmetic,' a system of computation that he initially proclaimed to 'entirely supersede the use of logarithms' and later developed into an elaborate system of 'dual logarithms.'

This talk surveys Byrne's mathematical works and their reception within the increasingly stratified community of 19th century British mathematical practitioners. In particular, we consider De Morgan's opinion of Byrne's work and reflect upon what it reveals about professional mathematics at the time. (Received September 16, 2012)

1086-01-932 **Della Dumbaugh*** (ddumbaugh@richmond.edu) and **Joachim Schwermer**. *Creating a Life: Emil Artin in America*.

In their preface to *The Collected Papers of Emil Artin*, Serge Lang and John Tate offer a succinct account of Artin's time in America. "He spent one year at the University of Notre Dame," they summarize, "then was at Indiana University in Bloomington from 1938 to 1946, at which time he moved to Princeton, where he stayed from 1946 to 1958. He returned to Hamburg in 1958." Artin died at the age of 64 on December 20, 1962. On this occasion near the fiftieth anniversary of Artin's death, this talk provides further insight into the years Artin spent in America and some of his contributions. (Received September 16, 2012)

1086-01-933 **Helena Durnova*** (helena.durnova@mail.muni.cz). *Using mathematical notation for programming computers*.

In mid-1950s, computer programmers across the Atlantic (members of the West-German GAMM and the American ACM) agreed on joining forces to design a new and better, indeed universal, language for programming computers. From the start, the opinion was voiced that this new language should be 'as close as possible to the mathematical notation'. While this requirement sounds natural in view of the use of the phrase mathematical machines to denote computers, it seems less natural when the profession of early programmers is taken into account: engineers, astronomers, and physicists. However, mathematics was probably the common language of them all.

In order to understand better the choice of programming language to be similar to mathematical notation, I will shortly turn back to the beginning of the 20th century to show how the development of mathematics as such as well as the development of the international mathematical community contributed to the special position of the mathematical notation, and hence also its 'only natural' usefulness for computer programming. (Received September 16, 2012)

- 1086-01-935 **Paul R Wolfson*** (pwolfson@wcupa.edu), Department of Mathematics, West Chester University, West Chester, PA 19383. *Elliptical Orbits and the Conflict over the Calculus*. Preliminary report.

In what has been called the central argument of the Principia, Isaac Newton derived the elliptical shape of the planets' orbits. In the years following its publication in 1687, however, this argument and other portions of the Principia received significant criticism from, among others, Johann Bernoulli. In this expository talk, I shall describe Newton's argument, the criticism it received, and Newton's rebuttal, all of which suggest some of the substantial issues in the conflict between the Newtonian and Leibnizian forms of the calculus. (Received September 16, 2012)

- 1086-01-956 **Kim Plofker*** (kim_plofker@alumni.brown.edu), Dept. of Mathematics, Union College, 807 Union Street, Schenectady, NY 12308. *Theory versus tables in second-millennium applied mathematics in India*. Preliminary report.

Beginning at least as early as the first millennium BCE, Sanskrit technical texts on astronomical computation provided challenges and applications for the development of Indian mathematics as well as preserving records of it. Towards the middle of the second millennium, a significant part of Sanskrit mathematical astronomy shifted its focus and format from the traditional verse treatises and handbooks to a bewildering variety of table texts. This talk explores the impact of this shift on technical and pedagogical aspects of the subject, as user-friendly tables grew in popularity and ingenuity. (Received September 17, 2012)

- 1086-01-993 **Lawrence A. D'Antonio*** (ldant@ramapo.edu), Ramapo College of New Jersey, Department of Mathematics, Mahwah, NJ 07430. *A Reader's Guide to the Classification of Quadratic Forms in the Disquisitiones Arithmeticae*. Preliminary report.

Gauss, in his Disquisitiones Arithmeticae, develops a rich, but confusing classification of quadratic forms. There are classes, orders, and genera of forms. In this talk we will explain this classification scheme using Gauss's own examples, ending with the statement of the Gauss class number conjectures. (Received September 17, 2012)

- 1086-01-1122 **MM Moazzam*** (mxmoazzam@salisbury.edu), Salisbury University Math Dept, Salisbury, MD 21801. *Mahani of Mahan: A persian Mathematician of Long Ago*. Preliminary report.

Mahani of Mahan, a Persian mathematician of long ago, is worthy of our consideration in this present time of technology and expansion. Mahani's contributions to mathematics are intriguing, and to learn about them increases an appreciation for early contributions to algebra, an important subject that is crucial for all mathematics curricula today. (Received September 19, 2012)

- 1086-01-1149 **Bruce J. Petrie*** (b.petrie@utoronto.ca). *Mathematical Notations as Identifiers of Epistemic Cultures*. Preliminary report.

Michael Mahoney (1993) observed that "The symbols and terms of modern mathematics are the bearers of its concepts and methods. Their application to historical material always involves the risk of imposing on that material a content it does not in fact possess." In making this observation Mahoney was influenced by Thomas Kuhn's writings on scientific change. *Revolutions in Mathematics* (Gillies, 1992) is a book dedicated to the integration of Kuhnian historiography and the history of mathematics. While Kuhn is well known, many historians of mathematics have yet to be introduced to the ideas of Karin Knorr Cetina, as presented in her *Epistemic Cultures: How the Sciences Make Knowledge* (1999). Knorr Cetina suggests that Kuhnian historiography is too narrow and proposes an alternative to the paradigm concept, that of epistemic culture. The paper documents the relevance of Knorr Cetina's conceptions to the history of mathematics and argues that there is an important reason to respect the distinctive notation and terminology of past mathematics: they are identifiers of epistemic cultures. (Received September 19, 2012)

- 1086-01-1199 **Nathan C Sidoli***, Waseda University, Tokyo, Japan. *Deductive structure and mathematical tables in Ptolemy's Almagest*. Preliminary report.

In this talk, I will address a number of interesting features of the mathematical tables in Ptolemy's *Almagest*. I will first discuss how they can be understood in terms of ideas related to mathematical functions, how they model geometric figures and allow a study of motion, and how they fit into the deductive framework of Ptolemy's approach. Finally, I will make some remarks about the different function of tables in Ptolemy's *Handy Tables*. (Received September 20, 2012)

1086-01-1337 **Eisso J. Atzema*** (atzema@math.umaine.edu). *The Reverend Thomas Hill (1818-1891): Educator, Administrator and Mathematician*. Preliminary report.

Nowadays, Thomas Hill (1818-1891) is perhaps best known as the immediate predecessor of Charles Elliot as president of Harvard College, a position which he held from 1862 to 1868. He also was president of tiny Antioch College for the two years preceding his tenure at Harvard, having succeeded Horace Mann as its first president. Before that, Hill was mostly known as a prominent unitarian minister, an educator and a promising mathematician. In this talk I will discuss the nature of his mathematical writings and how this work relates to Hill's other writings. In addition, I will discuss the influence of his teacher Benjamin Peirce. Focus will be on Hill's two published geometry textbooks as well as their unpublished sequel. (Received September 21, 2012)

1086-01-1368 **Andrew B Perry*** (perryand@gmail.com), 90 Longfellow Drive, Longmeadow, MA 01106. *Thomas Jefferson as Mathematician*.

Thomas Jefferson wrote in 1812: "When I was young, mathematics was the passion of my life." In fact he carried his passion for mathematics throughout his political career. Jefferson made a practical contribution to cryptography with his wheel cipher, formulated a method of congressional apportionment, championed a new decimal currency, and strongly and effectively advocated for mathematics education at two fledgling institutions of higher education, West Point and the University of Virginia. We consider these and many other aspects of Jefferson's involvement in mathematics. (Received September 25, 2012)

1086-01-1524 **Thomas Preveraud*** (thomaspreveraud@yahoo.com). *John Farrar's French mathematics textbooks translations for Harvard new curriculum (1818-1824)*.

In the mid-1810s, John Farrar, professor of mathematics and natural philosophy at Harvard College, convinced its president, John T. Kirkland, to give up the old mathematics course strongly influenced by English textbooks or their American versions. Two years later, Farrar published the first part of a new revolutionary teaching plan, *An Elementary Treatise on Arithmetic*, taken principally from the arithmetic of Lacroix, for the use of his students. From 1818 to 1824, Farrar would achieve the translation from the French of five other parts of his mathematics course, introducing to Harvard, among others, Lacroix's *Elements of Algebra* (1818), Legendre's *Elements of Geometry* (1819) and Bézout's *First Principles of Differential and Integral Calculus* (1824). With Farrar, Harvard led mathematics education in the United States in the 1820s. Our talk will first describe the origins and motivations of Farrar in this important educational change. The comparative analysis between the Farrar's works and the originals will then depict the specificity of his adaptations for American courses. Lastly, with the French textbooks, we'll show how Farrar introduced European continental mathematical content that had never been taught in America partly due to the conservatism of English colleges. (Received September 23, 2012)

1086-01-1533 **Charlotte K Simmons*** (cksimmons@uco.edu), 100 N. University Drive, Box 177, Edmond, OK 73034, and **Jesse W Byrne** (jbyrne@uco.edu), 100 N. University Drive, Box 129, Edmond, OK 73034. *Issai Schur*. Preliminary report.

Issai Schur (1875-1941) belongs "to those scattered over the earth" by the "Nazi storm," as Hirzebruch put it in his 1998 address to the International Congress of Mathematicians. This talk will examine the life and death of this remarkable mathematician whose lectures at the time of his dismissal from Berlin drew between 400 and 500 students; one student who had to be content with a seat in the back of the room, reported, "I used a pair of opera glasses to get at least a glimpse of the speaker." In addition, we will also investigate the role that German emigrants such as Issai's son Georg played on the development of the actuarial profession in Israel. (Received September 23, 2012)

1086-01-1598 **Sandro Caparrini*** (caparrini@libero.it), Sandro Caparrini, via Simeto, 3, 10043 Orbassano, Torino, Italy. *Who discovered vector calculus? The case of Domenico Chelini (1802-1878)*.

According to history books, vector calculus was invented by J. W. Gibbs and O. Heaviside (late 1870s) as a simplification of W. R. Hamilton's quaternions (1843). However, a closer look at the primary sources reveals that there were a number of mathematicians working on vector methods in mechanics and geometry during the first decades of the 19th century. We will consider the case of the Italian mathematician Domenico Chelini (1802-1878), who published a primitive formulation of elementary vector calculus as early as 1838 and applied it to differential geometry and mechanics in several papers. (Received September 23, 2012)

1086-01-1600 **Erik R. Tou*** (etou@carthage.edu), Carthage College, 2001 Alford Park Dr., Kenosha, WI 53140. *Did Bernoulli discover Bernoulli's equation?* Preliminary report.

Named for Daniel Bernoulli (1700-1782), the Bernoulli equation for fluid flow provides an inverse relationship between the pressure and velocity of an inviscid fluid—as velocity increases, pressure decreases. However, the equation has an exciting and convoluted history: its modern formulation is generally credited to Leonhard Euler (1707-1783), who was himself involved in a priority dispute between Bernoulli and his father, Johann.

In this talk, we sketch the evolution of Bernoulli's equation and examine the relationships between Euler and the two Bernoullis. Lastly, the equation will make a surprise appearance in a recently-translated paper of Euler's that predates his other works in fluid mechanics. (Received September 23, 2012)

1086-01-1697 **Janet L. Beery*** (janet_beery@redlands.edu). *Great minds think alike – when they share knowledge.* Preliminary report.

Matthias Schemmel has written about the “shared knowledge” of Thomas Harriot (1560-1621) and Galileo Galilei (1564-1642) and their resulting theories of projectile motion, and Kathleen Clark and Clemency Montelle have written about the “parallel insights” of John Napier (1550-1617) and Joost Burgi (1552-1632) on logarithms. In this presentation, we illustrate the shared knowledge and parallel insights of Harriot and Galileo, Harriot and Johann Faulhaber (1580-1635), and Harriot and Bartholomaeus Pitiscus (1561-1613) about, respectively, models of projectile motion, formulas for generalized triangular numbers (binomial coefficients), and constant difference interpolation techniques. (Received September 24, 2012)

1086-01-1706 **Young Hee Kye*** (yhkye@kosin.ac.kr), 194 Wachi-Ro, Yeoungdo-Gu, Busan, S. Korea, Busan, South Korea. *Paradigm and Pan-paradigm in Mathematics and Architecture.* Preliminary report.

Mathematics teaching is often more effective when teachers connect the contents of mathematics with history, culture, and social events. In the history of mathematics, the ‘paradigm’ theory from Thomas Kuhn's scientific revolution is very effective to explain the revolutionary process of development in mathematics, and his theory has been widely quoted in the history of science and economics. However, it has not been appropriate to use his theory in the other fields. This is due to the fact that the scope of Kuhn's paradigm theory is limited to mathematics and science. In this study, this researcher introduced pan-paradigm as a general concept that encompasses all, since through any relation in the field of mathematics and architecture, Thomas Kuhn's theory of paradigm does not explain the phenomena. That is, at the root of various cultures there exist always a ‘collective unconsciousness’ and ‘demands of the times,’ and these two factors by synergism form values and controlling principles common to various parts of the culture, and this synergism leads the cultural activities, the process of which is a phenomenon called pan-paradigm. (Received September 24, 2012)

1086-01-1861 **Laura E. Turner*** (lauraelizabeth.turner@utoronto.ca), IHPST, University of Toronto, Toronto, Ontario. *Analytic representation and the Mittag-Leffler “circle”: Contrasting notions of generality in the late 19th century.* Preliminary report.

Mittag-Leffler developed the theorem which bears his name between 1876 and 1884, following his apprenticeship in Berlin under Weierstrass, whose Factorization Theorem served as the point of departure for Mittag-Leffler's work. Where Weierstrass developed a representation for entire functions which displayed their zeros and their multiplicities, Mittag-Leffler focused on the analytic representation of functions with the most extensive possible set of singularities with the aim, from at least 1877, of representing those with even infinitely many essential singularities.

To Mittag-Leffler and Weierstrass, such analytic representations, fundamental to the Weierstrassian definition of a function itself, formed the most general “unit” of analysis. Indeed, studies devoted to the representation of functions were mainstream during this period. Yet others, and Cantor in particular, saw this dependence on analytic representations as problematic. His correspondence with Mittag-Leffler illuminates a shifting understanding of what it meant to be “general”, or “more general” in mathematics.

In this talk, I shall discuss the concept of “generality” foundational to the Mittag-Leffler Theorem, and consider the importance of this concept to some of Mittag-Leffler's contemporaries. (Received September 24, 2012)

1086-01-2296 **Chrs K. Caldwell*** (caldwell@utm.edu), Dept. of Math and Stat, 424 Andy Holt Humanities Building, University of Tennessee at Martin, Martin, TN 38238, and **Yeng Xiong**. *What was the smallest prime?*

What is the first prime? It seems that the number two should be the obvious answer, and today it is, but it was not always so. There were times when and mathematicians for whom the numbers one and three were acceptable

answers. To find the first prime, we must also know what the first positive integer is. Surprisingly, with the definitions used at various times throughout history, one was often not the first positive integer (some started with two, and a few with three). In this article, we survey the history of the primality of one, from the ancient Greeks to modern times. We will discuss some of the reasons definitions changed, and provide several examples. We will also discuss the last significant mathematicians to list the number one as prime. (Received September 25, 2012)

1086-01-2633 **Sanja V Pantić*** (pantic@math.uic.edu), MSCS Department, 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60607. *Historical survey of solitary wave phenomena*. Preliminary report.

In 1840's, mathematicians and scientists from the Royal Society were skeptical, despite Russell's observation, that a permanent, steady-propagating wave could exist on the surface of water. In order to unravel the reasons for their skepticism, we present the science that was available at the time regarding the discovery of solitary waves. We start with Euler's general system of equations that describe the motion of a perfect fluid and then discuss Lagrange's and Laplace's linearized equations for small amplitude waves and the French Academy of Science mathematical prize competition in 1813. We then travels from Paris to Oxford then Leipzig and Edinburgh meeting department chairs and professors, students and their famous tutors who contributed to shaping the mathematical world of fluid dynamics today.

By unifying the language that described wave motion at the time we show why Airy and Stokes doubted and opposed the existence of solitary waves. Then we give arguments in favor of their existence that followed through the work of Boussinesq. We then gave some perspective into different fields that found applications of solitary wave phenomena sometimes independently. (Received September 25, 2012)

03 ► *Mathematical logic and foundations*

1086-03-130 **Bradd Hart*** (hartb@mcmaster.ca), McMaster University, Mathematics and Statistics, 1280 Main Street, Hamilton, Ontario L8S 4K1, Canada. *John von Neumann, model theorist*.

I will survey some of the recent work on the model theory of operator algebras but will pay particular attention to some of the early work of von Neumann that turns out to be very relevant. (Received September 18, 2012)

1086-03-131 **Philipp Hieronymi*** (p@hieronymi.de), University of Illinois at Urbana-Champaign, Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Interpreting the projective hierarchy in expansions of the real line*.

We give a criterion when an expansion of the ordered set of real numbers defines the image of $(\mathbb{R}, +, \cdot, \mathbb{N})$ under a semialgebraic injection. This allows us to answer several questions raised by Chris Miller about expansions of the additive group of real numbers.

Theorem 1 ([1]). Let $\alpha \in \mathbb{R}$ be a non-quadratic irrational number and let $f : \mathbb{R} \rightarrow \mathbb{R}$ be the function that maps x to αx . Then $(\mathbb{R}, <, +, \mathbb{N}, f)$ defines multiplication on \mathbb{R} .

Theorem 2 ([1]). $(\mathbb{R}, <, +, \sin, \mathbb{N})$ defines multiplication on \mathbb{R} .

This is joint with Michael Tychonievich.

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(Received September 19, 2012)

1086-03-132 **Peter Koellner*** (koellner@fas.harvard.edu), Harvard University, Department of Philosophy, 320 Emerson Hall, Cambridge, MA 02138. *Reason and evidence in mathematics*.

In this talk I will address some of the general, structural features that arise in the case for new axioms. According to a traditional view axioms are “self-evident”. One difficulty with this view is that in foundational discussions there is often disagreement as to which statements are “self-evident”. Nevertheless, there is generally large agreement as to whether a given statement is “more evident” than another. For this reason, the relative notion is more suitable for articulating foundational disputes in mathematics. In the first part of the talk I will elucidate this relative notion by distinguishing it from kindred notions and by providing several examples. This will lead to what I will call the *evidentiary hierarchy*. In the second part of the talk I will use this framework to make a number of points concerning the case for new axioms. First, I will present what appears to be a strong argument

that the case for new axioms is ultimately doomed to fail. Second, I will argue that (at least in certain known cases) this problem can be overcome by appealing to reasons that involve deep mathematics. Finally, I will use this framework to place Harvey Friedman's program in philosophical perspective. (Received September 18, 2012)

1086-03-133 **Colin McLarty*** (colin.mclarty@case.edu), Case Western Reserve University, Philosophy and Mathematics, Cleveland, OH 44106. *Grothendieck's cohomology founded on finite order arithmetic.*

Despite rumors to the contrary, Grothendieck and others published proofs using Grothendieck universes, which are sets so large that ZF does not prove they exist. Number theorists to this day cite those published proofs. More conservative references avoid universes but still use far stronger set theory than the number theory requires, such as large amounts of replacement. We describe the issues and show how to formalize the entire Grothendieck apparatus at the strength of finite order arithmetic (simple type theory with infinity) and describes progress towards yet weaker foundations. (Received September 18, 2012)

1086-03-134 **Justin Moore*** (justin@math.cornell.edu), Cornell University, Department of Mathematics, Ithaca, NY 14853-4201. *Nonassociative Ramsey Theory and the amenability of Thompson's group.*

In 1973, Richard Thompson considered the question of whether his newly defined group F was amenable. The motivation for this problem stemmed from his observation — later rediscovered by Brin and Squire — that F did not contain a free group on two generators, thus making it a candidate for a counterexample to the von Neumann-Day problem. While the von Neumann-Day problem was solved by Ol'sanskii in the class of finitely generated groups and Ol'sanskii and Sapir in the class of finitely presented groups, the question of F 's amenability was sufficiently basic so as to become of interest in its own right.

In this talk, I will discuss my recent solution to this problem. The proof is obtained by exhibiting the existence of an idempotent measure on the free nonassociative groupoid on one generator. Such measures are necessarily invariant if this groupoid is identified in the standard way with the set of positive elements of F . The existence of the idempotent also has Ramsey-theoretic implications: it facilitates the proof of a generalization of Hindman's Theorem to the setting of nonassociative groupoids. (Received September 18, 2012)

1086-03-136 **Christian Rosendal*** (rosendal.math@gmail.com), University of Illinois at Chicago, Math., Statistics, and Computer Science, M/C 249, 851 S. Morgan Street, Chicago, IL 60607-7045. *Global and local boundedness properties in Polish groups.*

We present a comprehensive theory of boundedness properties for Polish groups developed with a main focus on Roelcke precompactness (precompactness of the lower uniformity) and Property (OB) (boundedness of all isometric actions on separable metric spaces). In particular, these properties are characterised by the orbit structure of isometric or continuous affine representations on separable Banach spaces. We further study local versions of boundedness properties and the microscopic structure of Polish groups and show how the latter relates to the local dynamics of isometric and affine actions. (Received September 18, 2012)

1086-03-327 **Douglas Cenzer*** (cenzer@ufl.edu), **Valentina Harizanov** and **Jeffrey B. Remmel**. *Effective Two-to-One Structures*. Preliminary report.

We examine structures of the form $A = (N, f)$ where f is a function from the natural numbers N to N such that at most two inputs map to the same output. If $|f^{-1}(a)| = 2$ for all a , then A is a two-to-one (2:1) structure. This extends previous work by the authors on injection structures. There are two types of orbits in a 2:1 structure. First, there are Z -chains with attached binary trees. This is an infinite sequence isomorphic to the integers Z , where each element maps to its successor, together with, for each point x in the Z -chain, a full binary tree in which each node maps to its predecessor and the top node maps to x . Second, there are k -cycles of the form $x, f(x), \dots, f^k(x) = x$, with binary trees attached to each node as for the Z -chains. The character of a 2:1 structure is specified by the number of k -cycles for each k . We show that, as for injection structures, a computable 2:1 structure exists for any Σ_2^0 character and with any number of Z -chains. We prove that a 2:1 structure is computably categorical if and only if it has finitely many Z -chains. Also, every computable 1:1 structure is Δ_2^0 categorical. We also examine the more complicated structures in which f is not surjective. (Received August 21, 2012)

1086-03-347 **Salilesh - Mukhopadhyay*** (smukhopadhyay@optonline.net), 8 Green Hill Road, Hackettstown, NJ 07840-5687. *The Mathematical Foundations Of Religion and Ethics*

The mathematical foundations of religion and ethics are explored through the algebraic and geometric approaches. Starting with the binary relation between a person and his or her faith an Abelian group is constructed with

ATMA [the soul] as the identity. The mathematical relation between man and God can be explained in two dimensions as follows: Man is an infinite circle whose circumference is nowhere, but whose center is located in one spot; and God is an infinite circle whose circumference is nowhere, but whose center is everywhere. An analytic comparison is made between Geometry [Mathematics] and Religion. Finally the geometry of truth is established through the domain of ignorance and the domain of enlightenment. (Received August 23, 2012)

1086-03-421 **Chris J. Conidis*** (chris.conidis@vanderbilt.edu) and **Richard A Shore** (shore@math.cornell.edu). *The complexity of ascendant sequences in locally nilpotent groups.*

We work in the context of locally nilpotent groups and cyclic ascendant subgroups.

The standard definition of an ascendant sequence requires quantification over all ordinals. For countable groups it is not difficult to show that we only need quantify over all countable ordinals, or all ordinals less than ω . This suggests that, computationally speaking, such sequences are complex and that for all natural numbers n one can construct a group with ascendant sequences computing the n^{th} iteration of Turing's Halting Set. However, our main result says that all cyclic (finitely generated) ascendant subgroups in locally nilpotent groups are uniformly computably enumerable with respect to the (finitely many) generator(s). This shows that ascendant sequences are actually (computationally speaking) very simple.

This is joint work with Richard Shore. (Received August 31, 2012)

1086-03-447 **Rodney Downey*** (rod.downey@vuw.ac.nz), PO Box 600, Wellington, 6140, New Zealand, and **Alexander Melnikov**, 50 Nanyang Avenue, Singapore, 639798, Singapore. *Effectively Categorical Torsion Free Abelian Groups.*

The effectiveness of the theory of abelian groups has been long studied beginning with the work of Mal'cev in the 60's. Nevertheless many problems remain. In this lecture I will discuss ongoing work on questions of effectiveness of categoricity for computable torsion-free abelian groups. The general problem is impossible; for example Downey and Montalbán showed that the isomorphism problem is Σ_1^1 -complete. The principle difficulty lies in the lack of invariants. However, where there are some invariants there we can salvage some effectiveness. The groups we look at are the completely decomposable ones, which have decompositions of the form $\oplus_{i \in \omega} G_i$ with G_i a subgroup of the additive group of the rationals. Such groups are called homogeneous if $G_i = H$ for all i . Alexander Melnikov and the author have shown that homogeneous computable completely decomposable groups are always Δ_3^0 categorical, this bound is sharp, and have classified when the groups are Δ_2^0 categorical in terms of what are called *semilow* sets. In more recent work, we have shown that every computable completely decomposable group is Δ_5^0 categorical and that this bound is sharp. (Received September 02, 2012)

1086-03-623 **Charles McCoy** (mccoy@up.edu), Mathematics Dept., University of Portland, 5000 N. Willamette Blvd., Portland, OR 97203-5798, and **Russell Miller*** (russell.miller@qc.cuny.edu), Mathematics Dept., Queens College - CUNY, 65-30 Kissena Blvd., Flushing, NY 11367. *Independent Sets in Computable Free Groups and Fields.* Preliminary report.

There is a strong analogy between the free group G on countably many generators and the purely transcendental field $F = \mathbb{Q}(X_1, X_2, \dots)$. Two notions of basis are relevant. An independent set generating G is known as a *basis* for the group, while an independent set generating the field F is called a *pure transcendence basis*. In fields, the term *transcendence basis* denotes any maximal independent set, whether or not it generates F ; the analogous notion for G is less common, and we simply call it a maximal independent set.

We establish various effectiveness properties of these notions in computable presentations of F and G . For F , the Turing degrees of transcendence bases form an upper cone above the degree of the dependence relation, which is always computably enumerable. In contrast, it is possible for a computable copy of G to have a computable maximal independent set, yet to have noncomputable dependence relation. When one considers independent generating sets, the situation changes: work of McCoy and Wallbaum established that for G , every computable presentation has a Π_2^0 basis, and that this bound is sharp, whereas for fields, many questions about the Turing degrees of pure transcendence bases remain open. (Received September 09, 2012)

1086-03-884 **Jesse W Johnson*** (jjohns27@nd.edu), University of Notre Dame, 255 Hurley Hall, Notre Dame, IN 46556. *Computable categoricity for quasiminimal-excellent classes.*

We define a type of classes important in modern model theory - the quasiminimal-excellent classes. Some examples of which are the algebraically-closed fields of characteristic 0, any strongly minimal theory (in a countable language with algebraic closure), and the theory of one equivalence relation whose blocks each have size \aleph_0 . We will concentrate on Zilber's "Pseudo-exponential fields" and his "covers of the multiplicative group of \mathbb{C} ." It is a

fact of Zilber that any quasiminimal-excellent theory is definable in $L_{\omega_1, \omega}(Q)$ and is categorical in all uncountable powers. We define a notion of computable structure theory in the uncountable setting to analyze the complexity of these isomorphisms. We show that for the pseudo-exponential fields, the isomorphism is Δ_2^0 -categorical, but not computably categorical. We also show that the multiplicative covers are relatively computably categorical. We generalize this idea to all quasiminimal-excellent classes and show that a quasiminimal-excellent class is computably categorical if and only if it is definable in $L_{\omega_1, \omega}$. (Received September 14, 2012)

1086-03-892 **Sergey S. Goncharov*** (s.s.goncharov@math.nsc.ru), Sobolev Institute of mathematics, Koptuga pr. 4, Novosibirsk, 630090, Russia. *Autostability relative to decidable representations.*

We are interested in decidable structures and some different computable representations of these structures. The basic definitions, results, and problems on this topic can be found in [1-4]. In this talk we will consider the problems about algorithmic theoretical-model properties of autostability relative to strong constructivization for models with decidable theories.

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1086-03-1033 **Paola D'Aquino, Salma Kuhlmann and Karen Lange*** (karen.lange@wellesley.edu), Department of Mathematics, Wellesley College, 106 Central St, Wellesley, MA 02481. *An algebraic characterization of recursively saturated real closed fields.*

We give a valuation theoretic characterization for a real closed field to be recursively saturated. This builds on work in in (KKMZ), where the authors gave such a characterization for κ -saturation, for a cardinal $\kappa \geq \aleph_0$. Our result extends the characterization of Harnik and Ressayre (HR) for a divisible ordered abelian group to be recursively saturated.

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(KKMZ) F.-V. Kuhlmann, S. Kuhlmann, M. Marshall, M. Zekavat, Embedding ordered fields in formal power series fields, *J. Pure Appl. Algebra* **169** 2002 71–90.

(Received September 18, 2012)

1086-03-1037 **Julia F. Knight*** (knight.1@nd.edu). *Uses of index set calculations.*

For a computable structure \mathcal{A} , the *index set*, $I(\mathcal{A})$, is the set of indices for computable copies of \mathcal{A} . For certain questions, not directly about index sets, we obtain answers using index set calculations. I will give examples of two different kinds.

- (1) Various familiar kinds of groups have simple descriptions. Index set calculations give us a way to test that a description is optimal. This is illustrated in known results on Abelian p -groups and free groups and in new work (joint with Vikram Saraph, an undergraduate) on torsion-free Abelian groups.
- (2) "Turing computable embeddings" (developed with graduate and undergraduate students) give an effective reduction of the isomorphism problem for one class of countable structures to that of another class. Many non-embeddability results reflect differences in the complexity of the sentences needed to distinguish among members of the two classes. Some new results, discovered jointly with a large group, involve model theoretic differences similar to Morley degree. The proofs of these results involve index set calculations.

(Received September 18, 2012)

1086-03-1345 **Asher M Kach, Karen Lange and Reed Solomon*** (david.solomon@uconn.edu), Department of Mathematics, University of Connecticut, U-3009, Storrs, CT 06269. *Turing degrees of orders on torsion-free abelian groups.*

The space of orders on a computable formally real field or computable torsion-free abelian group forms a Π_1^0 class. In the case of fields, one can represent any Π_1^0 class (up to Turing degree) by the space of orders in

some computable field. However, this property fails for computable abelian groups even for Π_1^0 classes which are classically homeomorphic to Cantor space. This talk will focus on a recent construction showing that for certain computable torsion-free abelian groups, one can always find a presentation for which the set of degrees of orderings is not upwards closed in the Turing degrees. (Received September 21, 2012)

1086-03-1570

Denis R. Hirschfeldt, Karen Lange and Richard A. Shore*

(shore@math.cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853. *Homogeneous Models and Weak Combinatorial Principles I.* Preliminary report.

This work has its roots in classical recursive model theory and the investigations by Goncharov and Peretyat'kin of the conditions under which a set of types over a complete decidable theory has a decidable homogeneous model realizing exactly the given set of types. We approached this problem from the viewpoint of reverse mathematics and discovered that there are several variants of the definitions of both homogeneity and of the effective conditions on the family of types that while classically equivalent are not so in RCA_0 . Instead one needs BS_2 or IS_2 to smooth the way. We also found an analogous result for when a complete decidable theory has a decidable model realizing exactly a given set of types.

Our next step was to search for natural combinatorial principles that would capture the effective constructions required.

This talk will describe the relevant definitions and results including the reverse mathematical one and so set the stage for the next talk by Denis Hirschfeldt which will describe the new combinatorial construction principles and how they power the effective model theory and interact with induction schemes in the setting of reverse mathematics. (Received September 23, 2012)

1086-03-1669

Valentina Harizanov* (harizanv@gwu.edu), Department of Mathematics, George

Washington University, Washington, DC 20052. *Complexity of orders on algebraic structures.*

A magma $\mathcal{M} = (M, *)$ is an algebraic structure with a single binary operation. Although $*$ does not have to be associative, familiar examples of magmas include semigroups and groups. A linear order $<$ of the domain M , which is left-invariant with respect to the operation $*$ is a left order on \mathcal{M} . If $<$ is also right-invariant, then it is a bi-order on \mathcal{M} . Interesting examples of nonassociative magmas that are right-orderable come from knot theory and are called quandles. There is a natural topology on the set of all left orders on \mathcal{M} , as well as on the set of all bi-orders on \mathcal{M} . These spaces are compact for any orderable magma, while for some well-known groups, they are even homeomorphic to the Cantor set. Not all computable orderable groups have a computable order. Downey and Kurtz showed that there is such an abelian group. We further investigate degree theoretic complexity of orders on groups. We also investigate when the space of left orders or bi-orders on familiar computable groups is homeomorphic to the Cantor set, and how this topological property relates to the computability theoretic complexity of orders. (Received September 24, 2012)

1086-03-1865

Yun Lu*, Mathematics Department, Kutztown University of PA, Kutztown, PA 19530.

Reducts of the Generalized Random Bipartite Graph. Preliminary report.

Let Γ be the generalized random bipartite graph that has two sides R_l and R_r with edges for every pair of vertices between R_l and R_r but no edges within each side, where all the edges are randomly colored by three colors P_1 , P_2 , and P_3 . In this talk, we investigate the reducts of Γ that preserve R_l and R_r , and classify the closed permutation subgroups in $\text{Sym}(R_l) \times \text{Sym}(R_r)$ containing the group $\text{Aut}(\Gamma)$. Our results rely on a combinatorial theorem of Nešetřil-Rödl and the strong finite submodel property of the generalized random bipartite graph. (Received September 24, 2012)

1086-03-2041

Denis R. Hirschfeldt* (drh@math.uchicago.edu), Department of Mathematics, The University of Chicago, 5734 S. University Ave., Chicago, IL 60637, and **Karen Lange** and **Richard A. Shore.** *Homogeneous Models and Weak Combinatorial Principles II.* Preliminary report.

Following up on the talk by Richard Shore, this talk will describe the new combinatorial principles arising from our work on homogeneous models, and their reverse mathematical interactions with model theoretic and induction principles. One family of principles we consider includes the principle $\Pi_1^0\text{G}$, which is closely related to the Atomic Model Theorem and was analyzed in the setting of reverse mathematics by Hirschfeldt, Shore, and Slaman [The Atomic Model Theorem and Type Omitting, Trans. Amer. Math. Soc. 361 (2009) 5805–5837]. This principle states that for any uniformly Π_1^0 collection of sets of strings D_0, D_1, \dots , each of which is dense in $2^{<\mathbb{N}}$, there is a generic real G meeting all of the D_i . We introduce a weaker principle $\Pi_1^0\text{GA}$ that posits not the

existence of G itself, but of an approximation to G . This principle is strictly weaker than IS_2 , but implies IS_2 over BS_2 . We also consider higher-level versions $\Pi_n^0\text{GA}$ that exhibit similar behavior. (Received September 24, 2012)

1086-03-2063 **Stephen Flood*** (sdf15@psu.edu). *The Logic of Graph Decompositions*. Preliminary report.

The theory of simplicial graph decompositions studies the infinite graphs that can be built using a sequence of irreducible graphs which are attached together at complete subgraphs. We study the strength of several “existence theorems”, which say that certain classes of graphs admit such a decomposition.

More formally, we say that a graph G has a *simplicial decomposition* $(B_\lambda)_{\lambda < \sigma}$ if σ is an ordinal, if $\{B_\lambda\}_{\lambda < \sigma}$ is a collection of induced subgraphs, and if three conditions hold: (1) $G = \bigcup_{\lambda < \sigma} B_\lambda$, (2) for each λ , the intersection of B_λ with $\bigcup_{\mu < \lambda} B_\mu$ is a complete graph, and (3) there are no “redundant” factors. A decomposition is *prime* if its factors cannot be decomposed further. There are a variety of existence theorems which say that certain graphs will admit a prime decomposition.

We will discuss the strength of a number of these existence theorems from the perspective of reverse mathematics and computability theory. In addition, we will give bounds on the ordinal length σ of prime decompositions for different graphs G . (Received September 24, 2012)

1086-03-2132 **Uri Andrews*** (andrews@math.wisc.edu), Department of Mathematics, University of Wisconsin, 480 Lincoln Dr., Madison, WI 53706, and **Alice Medvedev** (alice@math.berkeley.edu). *Recursive spectra of strongly minimal theories satisfying the Zilber trichotomy*.

We conjecture that for a strongly minimal theory T in a finite signature satisfying the Zilber Trichotomy, there are only three possibilities for the recursive spectrum of T : all countable models of T are recursively presentable; none of them are recursively presentable; or only the zero-dimensional model of T is recursively presentable. We prove this conjecture for disintegrated (formerly, trivial) theories and for modular groups. The conjecture also holds via known results for fields. The conjecture remains open for finite covers of groups and fields. (Received September 24, 2012)

1086-03-2225 **Ryan Holben*** (rho1ben@math.uci.edu). *Combinatorics at $\aleph_{\omega+1}$ in Prikry-type extensions*. Preliminary report.

We briefly explore some results about infinitary combinatorial principles at $\aleph_{\omega+1}$ in forcing extensions achieved from Prikry-type forcing. (Received September 25, 2012)

1086-03-2281 **Johanna N. Y. Franklin*** (johanna.franklin@uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, Unit 3009, Storrs, CT 06269-3009, and **Reed Solomon** (david.solomon@uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, Unit 3009, Storrs, CT 06269-3009. *Lowness for isomorphism*.

We bring the concept of lowness into computable structure theory and say that a Turing degree is low for isomorphism if, whenever it can compute an isomorphism between a pair of computable structures, there is actually a computable isomorphism between them. Several natural classes of Turing degrees, such as 2-generics, contain only degrees which are low for isomorphism. We present results illustrating how the class of low for isomorphism degrees relates to several classes of degrees that commonly appear in studies of lowness and discuss lowness for isomorphism in the context of particular types of structures. (Received September 25, 2012)

1086-03-2302 **William D. Simmons*** (simmons@math.uic.edu). *A computational approach to complete differential varieties (by way of model theory)*. Preliminary report.

The fundamental theorem of elimination theory asserts that projective varieties over an algebraically closed field K are *complete*. That is, if V is such a projective variety and W is any algebraic variety defined over K , then the projection $V \times W \rightarrow W$ takes Zariski closed sets to Zariski closed sets. Lou van den Dries described a quantifier elimination result for positive formulas that gives an easy proof of the fundamental theorem. W.Y. Pong applied van den Dries’ positive quantifier elimination to projective varieties over differentially closed fields of characteristic 0 (DCF_0). Here we use Pong’s criterion to give new examples of complete differential varieties and describe a computational approach intended to show that finite-dimensional projective differential varieties over DCF_0 are complete. This work is part of the author’s thesis research under David Marker. (Received September 25, 2012)

1086-03-2349 **Steven M. VanDenDriessche*** (svandend@nd.edu). *Coding sets in abelian p -groups.*

The class of countable reduced abelian p -groups is of much interest to both algebraists and logicians. In the context of logic, p -groups are exciting for two reasons. First, the invariants for classification are ordinal sequences of cardinals. Secondly, there is a nice relation between the invariants and the complexity of the sentences describing them. We give an overview of how this relation can be exploited in order to code a set into the ordinal sequence associated to the group, and how some tools from computable structure theory guarantee that there is an algorithm capable of doing the coding. (Received September 25, 2012)

1086-03-2568 **George M. Bergman*** (gbergman@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *Families of ultrafilters, and homomorphisms on infinite direct product algebras.*

In the preprint of which we will give some highlights, criteria are obtained for a filter \mathcal{F} of subsets of a set I to be an intersection of finitely many ultrafilters, respectively finitely many κ -complete ultrafilters for a given uncountable cardinal κ . Using these criteria, general results are deduced concerning homomorphisms on infinite direct product groups, yielding short proofs of some results in the literature: the Łoś-Eda theorem (on homomorphisms from a not-necessarily-countable direct product of modules to a slender module), and some results of N. Nahlus and the author on homomorphisms on direct products of not-necessarily-associative k -algebras. The same tools allow some related results to be strengthened, and yield an analog to one of these with nonabelian groups in place of k -algebras.

We briefly examine to what other structures the one might apply the methods that work, as noted above, for k -algebras on the one hand and for nonabelian groups on the other.

In a final section, the Erdős-Kaplansky Theorem on dimensions of vector spaces D^I (D a division ring) is extended to reduced products D^I/\mathcal{F} .

For the preprint, see http://math.berkeley.edu/~gbergman/papers/cap_ultra.pdf (Received September 25, 2012)

1086-03-2576 **Denis R. Hirschfeldt, Asher M. Kach*** (asher.kach@gmail.com) and **Antonio Montalban**. *A Finer Look at the Intermediate Degrees.*

For some classes of algebraic structures, it takes increasingly many jumps to decode information coded into a fixed isomorphism type. Feiner exploited such a relationship within the class of Boolean algebras to construct a Boolean algebra having presentations in a computably enumerable intermediate degree but not having computable presentations. In this talk, we begin by discussing this and other examples within various classes of algebraic structures.

After doing so, we introduce the Feiner Hierarchy and study the sets that are low and high for this hierarchy. In particular, we show the existence of intermediate computably enumerable degrees that are low, intermediate, and high for this hierarchy. (Received September 25, 2012)

1086-03-2791 **Michael Clare Manning*** (mcmanni3@asu.edu), 10518 South Greenfield Rd, Gilbert, AZ 85234. *Modeling Glioblastoma Growth Using a Poisson Process*. Preliminary report.

In this talk we consider stochastic models of Glioblastoma Multiforme brain tumors. We first look at a model by K. Swanson et al., which describes the dynamics as random diffusion plus deterministic logistic growth. We introduce a stochastic component in the logistic growth in the form of a random growth rate defined by a Poisson process. We show that this stochastic logistic growth model leads to a more accurate evaluation of the tumor growth compared its deterministic counterpart. We also discuss future plans to incorporate individual patient data into our model, in collaboration with a local hospital. (Received September 25, 2012)

05 ► Combinatorics

1086-05-16 **Alice Guionnet***, Ecole Normale Supérieure de Lyon, Lyon, France. *Free probability, Random matrices and map enumeration, II.*

Maps are connected graph which are properly embedded into a surface, their genus is the minimal genus of such a surface. Matrix integrals has been shown to be related with the enumeration of maps since the seventies, after the work of 't Hooft and Brézin-Itzykson-Parisi and Zuber. This is the so-called topological expansion. Such an expansion has been used in many fields of physics and mathematics. It will be at the center of this talk. Eventhough this talk is related with the previous one as free probability governs the first order of the expansion, this talk does not require to have followed the first talk. (Received April 10, 2012)

1086-05-35 **Andrew Vince*** (avince@ufl.edu), University of Florida, and **Miklos Bona** (bona@ufl.edu), University of Florida. *The Number of Ways to Assemble a Graph.*

Motivated by the question of how macromolecules assemble, the notion of an assembly tree of a graph is introduced. Given a graph G , the talk will be concerned with enumerating the number of assembly trees of G , a problem that applies to the macromolecular assembly problem. Explicit formulas or generating functions are provided for the number of assembly trees of several families of graphs, in particular for what we call H -graphs. In some natural special cases, recent results of Zeilberger and Apagodu on multivariate generating functions and results of Wimp and Zeilberger can be used to deduce precise asymptotic formulas. (Received June 11, 2012)

1086-05-63 **Linyuan Lu** (lu@math.sc.edu), **Austin Mohr*** (mohrat@email.sc.edu) and **László Székely** (szekely@math.sc.edu). *Quest for Negative Dependency Graphs.*

The Lovász Local Lemma is a well-known probabilistic technique commonly used to prove the existence of rare combinatorial objects. Its great success led to the development of the lopsided (or negative dependency graph) version of the lemma by Erdős and Spencer. In order to apply the lopsided lemma, the events of interest must satisfy a certain type of negative correlation that is easier to satisfy but harder to identify than the independence required by the original version. After familiarizing ourselves with the lopsided lemma, we will explore several settings involving disparate combinatorial objects in which proper negative dependency graphs have been discovered. (Received June 27, 2012)

1086-05-90 **Megan E. Heenehan*** (mheenehan@wesleyan.edu), Department of Mathematics and CS, Wesleyan University, 265 Church Street, Middletown, CT 06457, and **Karen L. Collins**. *Constructing Graphs with No Immersion of Large Complete Graphs.*

In 2003, Abu-Khazam and Langston conjectured that every d -chromatic graph contains an immersion of K_d . Lescure and Meyniel proved the conjecture for $d = 5, 6$ and DeVos, Kawarabayashi, Mohar, and Okamura proved the conjecture for $d = 5, 6, 7$. Both proofs use the fact that a d -critical graph has minimum degree at least $d - 1$. Seymour and later DeVos, Dvořák, Fox, McDonald, Mohar, and Scheide showed that the stronger conjecture that a graph with minimum degree $d - 1$ has an immersion of K_d fails for $d = 10$ and $d \geq 12$, but it is shown by DeVos et al. that a minimum degree of $200d$ does guarantee an immersion of K_d .

Here we will show that the stronger conjecture is false for $d \geq 8$ and give infinite families of examples with minimum degree $d - 1$ and chromatic number $d - 2$ or $d - 1$ that do not contain an immersion of K_d . We will give examples that can be up to $(d - 2)$ -edge-connected. We show, using Hajós' Construction, that there is an infinite class of non- $(d - 1)$ -colorable graphs that contain an immersion of K_d . We also make a conjecture for the minimum number of vertices that must have degree at least md , m a positive integer, to guarantee an immersion of K_d . (Received July 11, 2012)

1086-05-115 **Solomon Adegoke Osifodunrin*** (sosifodunrin@livingstone.edu), Department of Mathematics, Division of Sciences and Mathematics, Livingstone College, Salisbury, NC 28144. *Non-existence of difference sets with order $n = m^2$, where m is a natural number greater than 1.*

The existence of Hadamard $(4t - 1, 2t - 1, t - 1)$ difference sets in cyclic group provides a platform for solving the equation $\delta\bar{\delta} = n$ in the cyclotomic ring $\mathbb{Z}[\zeta_{4t-1}]$, where ζ_{4t-1} is root of unity, $n > 1$ and $t > 1$ are integers. We look at cases where $\langle n \rangle = \langle \delta \rangle \langle \bar{\delta} \rangle$ in $\mathbb{Z}[\zeta_{4t-1}]$ but $\delta\bar{\delta} = n$ has trivial solutions. This criterion is combined with other results to conclude non-existence of some difference sets. (Received July 23, 2012)

1086-05-141 **Maggie Miller***, Department of Mathematics, University of Texas, Austin, TX 78712, and **Brendan Shah**, School of Mathematical Sciences, Rochester Institute of Technology, Rochester, NY 14623. *Community Detection by Maximizing Partition Efficiency.*

We discuss how the measure of efficiency of a graph, proposed by V. Latora and M. Marchiori, can be used in community detection. We introduce a partitioning criteria called partition efficiency, which rewards well-connected clusters. Through spectral methods, we maximize this quantity via the second eigenvector of the efficiency matrix of an undirected graph. We apply this new method of graph partitioning to a U.S. Senate legislation network, and compare the maximum partition efficiency method to the community detection methods of maximum modularity, and information centrality. (Received July 27, 2012)

- 1086-05-142 **Bryan Ek***, School of Mathematical Sciences, Rochester Institute of Technology, Rochester, NY 14623-5604, and **Caitlin VerSchneider**, Department of Mathematics, Nazareth College, Rochester, NY 14618. *Efficiency of the Atlanta subway network and functional connectivity of the human brain.*

In 2001, Latora and Marchiori introduced the measure of efficiency between vertices in a graph. The efficiency between two vertices i and j is defined as the inverse of the corresponding distance. The global efficiency of a graph is the average of the efficiencies over all pairs of distinct vertices. We investigate the global efficiency of star-like networks, and show that networks of this type are very efficient. In particular we analyze the Metropolitan Atlanta Rapid Transit Authority (MARTA) Subway system, and show this network is 82 percent as efficient as a network where there is a direct line between every pair of stations. We determine global efficiencies for many families of graphs. We also consider two other measures of efficiency and connectivity. Given a graph G , let G_i denote the subgraph induced by the neighbors of vertex v_i . Then the local efficiency of G is the average of the global efficiencies of the subgraphs G_i . Also the clustering coefficient is the average number of edges in the subgraphs G_i . We present families of graphs where these two quantities are the same and others where they are very different. Finally we show how efficiency can be used to analyze functional connectivity of the human brain. (Received July 27, 2012)

- 1086-05-144 **Brianna Blake***, Department of Mathematics, Augsburg College, Minneapolis, MN 55454, and **Elizabeth Field**, Department of Mathematics, Southern Connecticut State University, New Haven, CT 06515. *Rank numbers of graphs that are combinations of paths and cycles.*

A k -ranking of a graph G is a function $f : V(G) \rightarrow \{1, 2, \dots, k\}$ such that if $f(u) = f(v)$ then every $u - v$ path contains a vertex w such that $f(w) > f(u)$. The rank number of G , denoted by $\chi_r(G)$, is the minimum k such that a k -ranking exists for G . It is shown that given a graph G and a positive integer t the question whether $\chi_r(G) \leq t$ is NP-complete. However, the rank number of numerous families of graphs have been established. We study and establish rank numbers of some more families of graphs that are combinations of paths and cycles. (Received July 27, 2012)

- 1086-05-170 **Joseph Frank DiNatale*** (jd4732@stu.armstrong.edu), 101 Royal Oak Court, Savannah, GA 31406. *Nim on Wheels.*

Nim is a popular combinatorial game in which two players alternate removing objects from piles. We consider a variation of Nim played on graphs as proposed in Masahiko Fukuyama's *Nim on Graphs*. In this version of Nim, two players alternate traversing the weighted edges of an undirected graph. A player moves by decreasing the weight value of an edge by a strictly nonnegative integer; when an edge's weight value is less than or equal to zero, the edge terminates. The player without any available moves loses. We extend Fukuyama's results by examining Nim played on wheel graphs and its winning strategies. (Received August 01, 2012)

- 1086-05-178 **Quinn Donahoe***, Department of Mathematics, Pennsylvania State University, State College, PA 16802, and **Jeremy Fehr**, Department of Mathematics, Wesleyan University, Middletown, CT 06459. *Ramsey Numbers $R(C_4, K_n)$, a Survey.*

The Ramsey number $R(C_4, K_n)$ is the smallest number m such that every graph on m vertices contains a C_4 or its complement contains a K_n . We provide an overview of methods that have been proven to be useful in calculating and bounding $R(C_4, K_n)$ for small n . We also summarize the techniques that have been used to prove the best-known bounds on the asymptotic behavior of $R(C_4, K_n)$. This includes our contribution of a constructive lower bound of $\Omega(n^{4/3})$ using a construction from finite geometry. (Received August 03, 2012)

- 1086-05-220 **Andrea Monterotti*** (amonerotti@students.stonehill.edu), Department of Mathematics, Stonehill College, Easton, MA 02357, and **Hsin-hao Su** (hsu@stonehill.edu), Department of Mathematics, Stonehill College, Easton, MA 02357. *The Edge-balance Index Set of Halin Graph of Double Stars.*

Let G be a simple graph with vertex set $V(G)$ and edge set $E(G)$. Any edge labeling f induces a partial vertex labeling $f^+ : V(G) \rightarrow \{0, 1\}$ depending on whether there are more 0-edges or 1-edges incident with v , and no label is given to $f^+(v)$ otherwise. For each $i \in \{0, 1\}$, let $v_f(i) = |\{v \in V(G) : f^+(v) = i\}|$ and let $e_f(i) = |\{e \in E(G) : f(e) = i\}|$. An edge-labeling f of G is said to be edge-friendly if $|\{e_f(0) - e_f(1)\}| \leq 1$. The edge-balance index set of G is defined as $\{|v_f(0) - v_f(1)| : \text{the edge labeling } f \text{ is edge-friendly}\}$.

Because of the definition of the edge-balance index, the calculation of the edge-balance index set depends highly on the structure of a graph. The general approach usually results an arithmetic progression. But, Chopra, Lee and Su discovered in 2010 that the values in an edge-balance index set of a wheel graph do not form an arithmetic progression.

A Halin Graph of a Double Star is a graph very similar to a wheel graph except there are two centers inside the outer cycle. We determined the exact values of the edge-balance index sets of Halin graphs of double stars, which do not form an arithmetic progression. (Received August 07, 2012)

1086-05-221 **Ryan Sullivan*** (rsullivan@students.stonehill.edu), Department of Mathematics, Stonehill College, Easton, MA 02357, and **Hsin-hao Su** (hsu@stonehill.edu), Department of Mathematics, Stonehill College, Easton, MA 02357. *The Edge-balance Index Set of Two and Three Level Wheels.*

Let G be a simple graph with vertex set $V(G)$ and edge set $E(G)$. Any edge labeling f induces a partial vertex labeling $f^+ : V(G) \rightarrow \{0, 1\}$ depending on whether there are more 0-edges or 1-edges incident with v , and no label is given to $f^+(v)$ otherwise. For each $i \in \{0, 1\}$, let $v_f(i) = |\{v \in V(G) : f^+(v) = i\}|$ and let $e_f(i) = |\{e \in E(G) : f(e) = i\}|$. An edge-labeling f of G is said to be edge-friendly if $|\{e_f(0) - e_f(1)\}| \leq 1$. The edge-balance index set of G is defined as $\{|v_f(0) - v_f(1)| : \text{the edge labeling } f \text{ is edge-friendly}\}$.

Because of the definition of the edge-balance index, the calculation of the edge-balance index set depends highly on the structure of a graph. A wheel graph is formed by a cycle with additional edges connected to a center vertex. Because the wheel graph is the first special graphs whose edge-balance index sets do not form an arithmetic progression, we generalized it into two or three level wheels by adding one or two more layers of cycles with connecting edges. In this paper, we determined the exact values of the edge-balance index sets of two or three level wheels. (Received August 07, 2012)

1086-05-222 **Matt Tardiff*** (mtardiff@students.stonehill.edu), Department of Mathematics, Stonehill College, Easton, MA 02357, and **Hsin-hao Su** (hsu@stonehill.edu), Department of Mathematics, Stonehill College, Easton, MA 02357. *On Mod(3) Edge-magic Cubic Graphs.*

Let G be a (p, q) -graph in which the edges are labeled by $1, 2, \dots, q$. The vertex sum for a vertex v is the sum of the labels of the incident edges at v . If the vertex sums are constant, $(\text{mod } k)$, where $k > 2$, then G is said to be $\text{Mod}(k)$ -edge-magic. When $k = p$, the $\text{Mod}(p)$ -edge-magic graph is the edge-magic graph which was introduced by Lee, Seah and Tan in 1992.

When we consider whether a cubic graph is $\text{Mod}(3)$ -edge-magic, an old theorem stated “almost all cubic simple graphs are $\text{Mod}(3)$ -edge-magic.” So, a conjecture, “all cubic simple graphs are $\text{Mod}(3)$ -edge-magic” has been around for more than fifteen years and is still not completely solved. While a power theorem, if a cubic graph is Hamiltonian then it is $\text{Mod}(3)$ -edge-magic, takes care of most of cubic graphs, in this paper, we investigate non-Hamiltonian graphs which are $\text{Mod}(3)$ -edge-magic. (Received August 07, 2012)

1086-05-223 **Neal Madras** (madras@mathstat.yorku.ca) and **Lerna Pehlivan*** (pehlivan@mathstat.yorku.ca), Department of Mathematics and Statistics, N520 Ross, 4700 Keele Street, Toronto, M3J 1P3, Canada. *312-Pattern Avoiding Permutations With Determined Points.* Preliminary report.

We study the 312-pattern avoiding permutations in S_n that has one determined point below the diagonal as well as the 312-pattern avoiding permutations with two determined points below the diagonal. We provide the formulas for the probabilities of having such permutations and we look at the approximations of the probabilities when n is large. Moreover, we determine the expected value and the variance of 312-pattern avoiding permutations with determined points below the diagonal. (Received August 07, 2012)

1086-05-229 **Edward L Richmond*** (erichmond@math.ubc.ca), University of British Columbia, Department of Mathematics, 1984 Mathematics Rd, Vancouver, BC V6T 1Z2, Canada, and **William Slofstra.** *Coxeter groups, palindromic Poincaré polynomials and triangle group avoidance.* Preliminary report.

Let W be a Coxeter group. For any w in W , let P_w denote the Poincaré polynomial of w (i.e. the generating function of the principle order ideal of w with respect to length). If W is the Weyl group of some Kac-Moody group G , then P_w is the usual Poincaré polynomial of the corresponding Schubert variety X_w .

In this talk, I will discuss joint work with W. Slofstra on detecting when the sequence of coefficients of a Poincaré polynomial are the same read forwards and backwards (i.e. palindromic). The polynomial P_w satisfies this property precisely when the Schubert variety X_w is rationally smooth. It turns out that this property is easy to detect when the Coxeter group W avoids certain rank 3 parabolic subgroups (triangle groups). One consequence is that, for many Coxeter groups, the number of elements with palindromic Poincaré polynomials is finite. Explicit enumerations and descriptions of these elements are given in special cases. (Received August 09, 2012)

- 1086-05-239 **Lianzhu Zhang, Weifan Wang and Ko-Wei Lih*** (makwlih@sinica.edu.tw), P.O. Box 23-216 Taipei, Taipei City, 10699, Taiwan. *An improved upper bound on the adjacent vertex distinguishing chromatic index of a graph.*

An adjacent vertex distinguishing coloring of a graph G is a proper edge coloring of G such that any pair of adjacent vertices are incident with distinct sets of colors. The minimum number of colors needed for an adjacent vertex distinguishing coloring of G is denoted by $\chi'_a(G)$. In this paper, we prove that $\chi'_a(G) \leq \frac{5}{2}(\Delta + 2)$ for any graph G having maximum degree Δ and no isolated edges. This improves a result in [S. Akbari, H. Bidkhori, N. Nosrati, r -Strong edge colorings of graphs, Discrete Math. 306 (2006), 3005-3010], which states that $\chi'_a(G) \leq 3\Delta$ for any graph G without isolated edges. (Received August 11, 2012)

- 1086-05-240 **Jennifer A. Koonz*** (koonz@math.umass.edu), Department of Mathematics and Statistics, Lederle Graduate Research Tower, University of Massachusetts, Amherst, MA 01003-9305. *New Combinatorial Methods for Computing the Intersection Cohomology Poincaré Polynomial for Schubert Varieties.*

We have defined a new polynomial which predicts the dimensions of the intersection cohomology groups of singular Schubert varieties in certain cases, including some non-rationally smooth cases. (Received August 11, 2012)

- 1086-05-253 **Anton Betten*** (betten@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523. *Breaking Symmetry In the Computer Age.*

The old technique of breaking symmetry is popular in proofs (We may assume...). Today, we can use computers to examine many cases in very little time. Using symmetry means that we examine only the cases that are distinct. This is useful for classifying discrete objects by computer (which is a difficult problem because it involves isomorphism testing). Beyond breaking the symmetry, we use techniques from graph theory. Specifically, we use rainbow cliques in colored graphs to make the search feasible. Exotic objects like BLT-sets, unitals in projective planes, translation planes, dual hyperovals and others can all be classified with this method. Summarizing, we obtain efficient algorithms to deal with the isomorphism problem. (Received September 10, 2012)

- 1086-05-276 **Tom Halverson*** (halverson@macalester.edu), Macalester College, Saint Paul, MN 55105. *Combinatorial Gelfand Models for Diagram Algebras.*

A Gelfand model (or model) for a semisimple algebra A is a complex linear representation that contains each irreducible representation of A with multiplicity exactly one. We derive a method of explicitly constructing models that works simultaneously for a large class of diagram algebras including: the partition, Brauer, rook monoid, rook-Brauer, Temperley-Lieb, Motzkin, and planar rook monoid algebras. In each case, diagrams act by "signed conjugation" on the linear span of their vertically symmetric diagrams. This model representation is a generalization of the Saxl model for the symmetric group, and, in fact, our method is to use the Jones basic construction to lift the Saxl model from the symmetric group to a model for each diagram algebra. In the case of the planar diagram algebras (Temperley-Lieb, Motzkin, planar rook monoid), our construction exactly produces the irreducible representations of the algebra. (Received August 15, 2012)

- 1086-05-324 **Luke F Naftz*** (lfnftz@gmail.com) and **Tyler Hays**. *The Edge Coloring Game on Extended Stars.*

The edge coloring game is a two-player game that is played on the edges of a graph G , with $\Delta(G) = \Delta$. We consider this game on a class of graphs called extended stars and partially extended stars. If G is an extended star, we will show the game chromatic index of G is $\Delta + 1$. We briefly consider the class of partial extended stars. If the graph G is a partially extended star, we show the game chromatic index of G is $\Delta + 1$ or Δ , depending on the structure. (Received September 12, 2012)

- 1086-05-335 **Cristian Lenart, Satoshi Naito, Daisuke Sagaki, Anne Schilling and Mark Shimozono*** (mshimo@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061. *Level zero Littelmann paths, Kirillov-Reshetikhin crystals, parabolic quantum Bruhat graph, and Macdonald polynomials.*

We give several explicit combinatorial formulas for the specialization of a Macdonald polynomial $P_\lambda(x; q, t)$ at $t = 0$. For simply-laced type, Ion showed that $P_\lambda(x; 1, 0)$ is a Demazure character in a highest weight crystal for the untwisted affine algebra, and Fourier and Littelmann proved that this character is a product of fundamental Kirillov-Reshetikhin (KR) characters. In general type, the Macdonald specialization is not a Demazure character. However we prove that $P_\lambda(x; q, 0)$ is the product of KR characters, graded by the energy function. Along the way we obtain several explicit combinatorial formulas for this graded character: (1) Lakshmibai-Seshadri (canonical Littelmann) paths for a level-zero weight for the untwisted affine algebra, projected to the finite weight lattice; (2)

certain walks in the parabolic quantum Bruhat graph, which comes from quantum cohomology of homogeneous spaces; (3) alcove walks controlled by the Borel quantum Bruhat graph. (Received August 22, 2012)

1086-05-358 **Greg Kuperberg*** (greg@math.ucdavis.edu), **Shachar Lovett** (slovett@math.ias.edu) and **Ron Peled** (peledron@post.tau.ac.il). *Probabilistic existence of combinatorial and geometric t -designs.*

A t -design on an affine real algebraic variety with a measure is a finite set whose moments up to degree t match those of the measure on the whole space. This definition includes both combinatorial t -designs (sets of k -subsets of a v -set that cover each t -set the same number of times) and geometric t -designs, which includes t -designs on a sphere surface.

Two fundamental theorems, Tierlinck's theorem in the combinatorial case and the Seymour-Zaslavsky theorem in the spherical case, say simply that a non-trivial t -design exists for every t . These results were originally proved constructively, but with poor or highly restricted asymptotics.

We discuss a new approach to both theorems based on simply picking a set of points at random. The chance that the set is a t -design is very small, but in a favorable regime it can be estimated and is positive. In the geometric case the probability of success is exactly zero, but the probability density is positive, which suffices. (Received August 24, 2012)

1086-05-393 **Hoang Ngoc Minh*** (hoang@lille2.fr), 59024 Lille, France, and **Gérard H.E. Duchamp**. *A differential theorem and its application to evaluations of special functions at some singularities.*

In this contribution, we present applications of an abstract differential theorem. This implies that, given a family of differential forms (with possible singularities) over a Riemannian surface of dimension one, the corresponding Chen generating series is a universal character of the \mathcal{C} -shuffle algebra (\mathcal{C} is the field of functions which serves as scalars). The algebra of solutions can be computed by a simple algorithm. This algorithm is a (noncommutative) integrator which (under mild conditions \mathcal{C}), provides a transcendence basis of this algebra. From this, we discuss other algebraic relations of the numerical range of this basis which appear when one specializes it to well-chosen values. (Received August 28, 2012)

1086-05-400 **Jonah Blasiak*** (jblasiak@gmail.com). *Kronecker coefficients for one hook shape.*
The Kronecker coefficient $g_{\lambda\mu\nu}$ is the multiplicity of an irreducible \mathcal{S}_n -module M_ν in the tensor product $M_\lambda \otimes M_\mu$. A fundamental open problem in algebraic combinatorics is to find a positive combinatorial formula for these coefficients. We give such a formula in the case that one of the partitions is a hook shape. Our main tool is Haiman's *mixed insertion*, which is a generalization of Schensted insertion to colored words. (Received August 29, 2012)

1086-05-405 **Alexander H. Sistko*** (asistko@gmail.com), 1501 W. Bradley Avenue, Peoria, IL 61625, **Lawrence Barrett** (ninobarrett@comcast.net), 500 Joseph C. Wilson Boulevard, Rochester, NY 14627, **John Portin** (jportin@linfield.edu), 900 SE Baker St., McMinnville, OR 97128, and **Susan Rufai**, McMinnville, OR 97128. *Relaxed Coloring Games on Complete Multipartite Graphs.*

Let G be a finite graph, k a positive integer, and d a non-negative integer. We consider a game in which two players, Alice and Bob, take turns coloring the vertices of G from a set of k colors. Every vertex with color α can be adjacent to at most d vertices already colored α . Alice wins if every vertex of G is eventually colored; otherwise Bob wins. This game is called the (d, k) -relaxed coloring game on G . We are interested in the least k such that Alice has a winning strategy for this game. This parameter is called the d -relaxed game chromatic number of G , and is denoted by ${}^d\chi_g(G)$. In this talk, we discuss ${}^d\chi_g(G)$ where G is a complete multipartite graph and $d \leq 2$, focusing on the case $d = 2$. (Received August 29, 2012)

1086-05-416 **Kate Rudolph*** (k8r@mit.edu). *Pattern Popularity in 132-avoiding Permutations.*
The popularity of a pattern p is the total number of copies of p within all permutations of a set. We address popularity in the set of 132-avoiding permutations. Bóna showed that in this set, all other non-monotone length-3 patterns are equipopular, and proved equipopularity relations between some length- k patterns of a specific form. We prove equipopularity relations between general length- k patterns, based on the structure of their corresponding binary plane trees. Our result explains all equipopularity relations for patterns of length up to 7, and we conjecture that it provides a complete classification of equipopularity in 132-avoiding permutations. (Received August 30, 2012)

1086-05-440 **Brittany Shelton*** (bcs207@lehig.edu), 14 E. Packer Ave, Christmas-Saucon, Bethlehem, PA 18015, and **Mark Skandera** (mas906@lehig.edu), 14 E. Packer Ave, Christmas-Saucon, Bethlehem, PA 18015. *Path tableaux and Hecke algebra characters.*

For each matrix representation of the symmetric group of order n there is a class function mapping each element to the trace of its matrix representation. Such functions are called symmetric group characters. Path tableaux, generalizations of Young tableaux, have been shown to be a combinatorial interpretation of the coefficients of symmetric group characters applied to special generating functions. Extending these interpretations to the quantum analog of the symmetric group characters, the Hecke algebra characters, remains an open problem. (Received September 01, 2012)

1086-05-452 **Ping Ngai Chung*** (briancpn@mit.edu), 305 Memorial Drive, Cambridge, MA 02139. *On the c -strong Chromatic Number of t -intersecting Hypergraphs.* Preliminary report.

For a fixed $c \geq 2$, a c -strong coloring of the hypergraph G is a vertex coloring such that each edge e of G covers vertices with at least $\min\{c, |e|\}$ distinct colors. A hypergraph is t -intersecting if the intersection of any two of its edges contains at least t vertices. This paper addresses the question: what is the minimum number of colors which suffices to c -strong color any t -intersecting hypergraph? We first show that the number of colors required to c -strong color a graph of size n is $O(\sqrt{n})$. Then we prove that we can use finitely many colors to 3-strong color any 2-intersecting hypergraphs. Finally, we show that $2c-1$ colors are enough to c -strong color any shifted $(c-1)$ -intersecting hypergraphs, and $2c-2$ colors are enough to c -strong color any shifted t -intersecting hypergraphs for $t \geq c$, both chromatic numbers are optimal and match the conjectures by Blais, Weinstein and Yoshida, who conjectured that the shifted condition can be removed. (Received September 03, 2012)

1086-05-481 **Breeanne Baker*** (bab207@lehig.edu). *The 1-Fixed-Endpoint Path Partition Problem on Interval Graphs.*

Given a graph G and a vertex t , a 1-fixed-endpoint path partition of G with respect to t is a set of vertex-disjoint paths which cover the vertices of G and in which t is an endpoint of a path. The 1-fixed-endpoint path partition problem is to find the minimum size of such a path partition. In general, this problem is NP-hard; however, there exists a min-max theorem which describes this value when G is an interval graph. (Received September 04, 2012)

1086-05-490 **Alexandr Kostochka** and **Matthew Yancey*** (yancey1@illinois.edu). *Ore's Conjecture on color-critical graphs is almost true.*

A graph G is k -critical if it has chromatic number k , but every proper subgraph of G is $(k-1)$ -colorable. Let $f_k(n)$ denote the minimum number of edges in an n -vertex k -critical graph. We give a lower bound, $f_k(n) \geq F(k, n)$, that is sharp for every $n = 1 \pmod{k-1}$. It is also sharp for $k = 4$ and every $n \geq 6$. The result improves the classical bounds by Gallai and Dirac and subsequent bounds by Krivelevich and Kostochka and Stiebitz. It establishes the asymptotics of $f_k(n)$ for every fixed k . It also proves that the conjecture by Ore from 1967 that for every $k \geq 4$ and $n \geq k+2$, $f_k(n+k-1) = f(n) + \frac{k-1}{2}(k - \frac{2}{k-1})$ holds for each $k \geq 4$ for all but at most $k^3/12$ values of n . We will also characterize all k -critical graphs for which $|E(G)| = F(k, |V(G)|)$. (Received September 04, 2012)

1086-05-492 **Joseph Chaffee*** (chaffjr@auburn.edu) and **Chris Rodger**. *Quadratic Leaves of Partial Triple Systems.*

It is well known that a λ -fold Steiner triple system on n points is equivalent to a K_3 -decomposition of λK_n . Necessary and sufficient conditions for λ -fold Steiner triple systems are also well known. A partial triple system is a partial decomposition of λK_n into K_3 (so we use some but maybe not all of the edges in λK_n). The leave of a partial triple system, for the purposes of this talk, is the graph on n vertices that consists of all edges of λK_n not used in a K_3 . In this talk, we discuss partial triple systems and what graphs can be leaves of partial triple systems. In particular, we focus on quadratic leaves (a quadratic graph is a graph in which each vertex has degree 2 or 0) and extend two well-known results of Rosa and Colbourn. (Received September 04, 2012)

1086-05-541 **Sergi Elizalde*** (sergi.elizalde@dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755. *The most and the least avoided consecutive patterns.*

A permutation π avoids a consecutive pattern σ if no subsequence of adjacent entries of π is in the same relative order as the entries of σ .

I will show that the number of permutations avoiding the consecutive pattern $12\dots m$ —that is, containing no m adjacent entries in increasing order—is asymptotically larger than the number of permutations avoiding any other consecutive pattern of length m . This had been conjectured in 2001 by Elizalde and Noy. At the other

end of the spectrum, the number of permutations avoiding $12 \dots (m-2)m(m-1)$ is asymptotically smaller than for any other consecutive pattern. This had been recently conjectured by Nakamura.

The techniques used include the cluster method of Goulden and Jackson, an interpretation of clusters as linear extensions of posets, and singularity analysis of generating functions. (Received September 06, 2012)

1086-05-542 **Lindsay A Erickson*** (lerick15@cord.edu), ND, and **Warren E Shreve** (warren.shreve@ndsu.edu). *Advances in edge Nim on graphs.*

The two-player game of Nim on graphs is played on a regular graph with positive integrally weighted edges by moving alternately from a fixed starting vertex to an adjacent vertex, decreasing the weight of the incident edge to a strictly smaller non-negative integer. The game ends when the losing player is unable to move. In this paper, we discuss some recent advances in the finding the winner of the game. Specifically, we discuss Nim on multipartite graphs, including the solution for a large class of bipartite graphs. Also, we discuss work done on the arbitrarily weighted Petersen graph, as well as provide a complete solution for unit weight hypercubes and discuss work on arbitrarily weighted hypercubes. (Received September 06, 2012)

1086-05-551 **Andrew W. Harrell*** (aharel@netdoor.com), 3000 Drummond St., Vicksburg, MS 39180. *Counting Backtracking Path Searches in Network Graphs.*

Most of the networking optimization and search algorithms use a node labeling procedure to reduce the number of search paths used in the problem's algorithms. But, the approach I used, to solve problems of unit routing through movement corridors of digital map networks, saves the partial paths used in the search and backtracks through a more complete enumeration of non-cyclic goal searches: ['A Logic Programming Approach to Network Flow Algorithms', Transactions of the Eighth Army Conference on Applied Mathematics and Computing, ARO Report 91-1, Durham, North Carolina]. It is an interesting problem in combinatorial graph theory to compute formulas, in terms of in-going and out-going edges from graph nodes, for the number of path searches used in these algorithms. In this talk I will define several terms related to these computations and suggest some results and formulas that may have applications to many other problems in network optimization and AI expert system, knowledge software design. (Received September 06, 2012)

1086-05-562 **Igor Pak***, Department of Mathematics, UCLA, Los Angeles, CA 90095. *Cayley's partition identity.*

I will present a short bijective proof of Cayley's 1857 partition identity and discuss some easy consequences. I will also elaborate on why this bijection has not been found until now. Joint work with Matjaz Konvalinka. (Received September 07, 2012)

1086-05-572 **Shirley Elizabeth Law*** (selaw@ncsu.edu). *The Hopf Algebra of Sashes.*

A general lattice theoretic construction of Reading constructs Hopf subalgebras of the Malvenuto-Reutenauer Hopf algebra (MR) of permutations. The products and coproducts in these Hopf subalgebras are defined extrinsically in terms of the embedding in MR. The goal of this research is to find an intrinsic combinatorial description of a particular family of these Hopf subalgebras. The simplest Hopf algebra in the family has a natural basis given by permutations that I call Pell permutations. The Pell permutations are in bijection with combinatorial objects that I call sashes; that is, tilings of a 1 by n rectangle with three types of tiles: black 1 by 1 squares, white 1 by 1 squares, and white 1 by 2 rectangles. The bijection induces a Hopf algebra structure on sashes. I will describe the product and coproduct in terms of sashes, and the natural partial order on sashes. I also will discuss how the Hopf subalgebra relates to the larger family of Hopf subalgebras. (Received September 07, 2012)

1086-05-576 **Neil Hindman** and **Dev Phulara*** (phulara@comcast.net). *Some new additive and multiplicative Ramsey numbers.*

For $a, r \in \mathbb{N}$, the set of positive integers, define $FSP_2(a, r)$ (respectively $SP_2(a, r)$) to be the first $n \in \mathbb{N}$, if such exists, such that whenever $\{1, 2, \dots, n\}$ is r -colored, there exist x and y with $a \leq x < y$ such that $\{x, y, x+y, xy\}$ is monochromatic (respectively $\{x+y, xy\}$ is monochromatic). If no such n exists, the number is defined to be infinite. It is an old result of R. Graham that $SP_2(a, 2)$ is finite for all a . With that exception, the only cases (with $r > 1$) for which $FSP_2(a, r)$ or $SP_2(a, r)$ are known to be finite are those for which explicit values have been computed. We provide exact values of $FSP_2(a, 2)$ for $a \leq 5$ (of which $FSP_2(1, 2)$ and $FSP_2(2, 2)$ were previously known). We provide exact values of $SP_2(a, 3)$ for $a \leq 8$ and exact values of $SP_2(a, 2)$ for $a \leq 60$. We also compute upper and lower bounds for $SP_2(a, 2)$. (Received September 07, 2012)

1086-05-591 **Sergey Yekhanin*** (yekhanin@microsoft.com). *On the locality of codeword symbols.*

Consider a linear systematic code C . We say that the i -th coordinate of C has locality r ; if the value at this coordinate can be recovered from accessing some other r coordinates of C . Data storage applications require codes with small redundancy, low locality for information coordinates, and high erasure correction capabilities. In this talk I will survey a line of work studying the relations between these parameters.

Based on joint papers with Michael Forbes, Parikshit Gopalan, Cheng Huang, and Huseyin Simitci. (Received September 07, 2012)

1086-05-615 **Tyler Hays*** (tyhays@gmail.com) and **Luke Naftz** (lnaftz@gmail.com). *The Total Coloring Game.* Preliminary report.

We investigate a variation on competitive graph coloring called total game coloring in which two players take turns coloring uncolored vertices and edges of a graph G while respecting certain restrictions. We define a generalization of the game chromatic number of a graph G called the *total game chromatic number*, denoted $\chi_g''(G)$. We prove the bounds $\chi_g''(F) \leq \Delta(F) + 4$ for forest F , $\chi_g''(G) \leq \Delta(G) + 3k + 2$ for chordal graphs with $\omega(G) = k + 1$, and $\chi_g''(G) \leq \Delta(G) + 7$ for maximally outerplanar graphs. (Received September 09, 2012)

1086-05-625 **Ira M. Gessel*** (gessel@brandeis.edu), Department of Mathematics, MS 050, Brandeis University, Waltham, MA 02453. *The Carlitz-Scoville-Vaughan theorem and its applications to permutation enumeration.* Preliminary report.

In 1976 Carlitz, Scoville, and Vaughan proved a simple, but fundamental result about the enumeration of words with restrictions on adjacent letters:

Let A be an alphabet and let R be a relation on A , that is, a subset of $A \times A$. Let A^R be the set of all words $a_1 a_2 \cdots a_k$ on A , for all k , with $a_j a_{j+1} \in R$ for $1 \leq j \leq k - 1$. (Thus the empty word and all one-letter words are in A^R .) Let $\bar{R} = A \times A - R$. Then the Carlitz-Scoville-Vaughan theorem asserts that

$$\sum_{w \in A^R} w = \left(\sum_{w \in A^{\bar{R}}} (-1)^{|w|} w \right)^{-1},$$

where $|w|$ is the length of w .

The Carlitz-Scoville-Vaughan theorem deserves to be much better known than it is. I will explain how it can be applied to many interesting permutation enumeration problems, such as counting permutations with periodic run lengths and counting pairs of permutations with no common descents. (Received September 09, 2012)

1086-05-628 **Andrew M Baxter*** (baxter@math.psu.edu). *Counting copies of vincular patterns among pattern-avoiding permutations.* Preliminary report.

Let $S_n(B)$ be the set of n -permutations avoiding a set of vincular patterns B . For a vincular pattern σ , we are interested in the distribution of the statistic “number of copies of σ ” over $S_n(B)$. For example, the descent statistic can be rephrased as the number of copies of 21, which has the distribution $1 + 3q + q^2$ over $S_3(1-3-2)$.

Enumeration schemes encode polynomial-time recurrences to compute $|S_n(B)|$. We will demonstrate how to decode the same structures to build recurrences to compute distributions of various permutation statistics over $S_n(B)$, including the “copies of σ ” statistic above when σ is a consecutive pattern or has the form $\sigma_1 \cdots \sigma_m - \sigma_{m+1}$.

As an application of these ideas, we will demonstrate several theorems and conjectures related to the total number of copies of a consecutive pattern over $S_n(B)$ for different small sets B . (Received September 09, 2012)

1086-05-682 **Heather Dye** and **Patricia Hersh*** (plhersh@ncsu.edu), Patricia Hersh, Box 8205, North Carolina State University, Raleigh, NC 27695-8205, and **Karola Meszaros** and **Bridget Tenner**. *Homotopy type of a noncommutative analogue for Young’s lattice.*

Bessenrodt, Haglund, Luoto, Mason and van Willigenburg recently introduced quasisymmetric and noncommutative analogues of Schur functions. Associated to these are analogues of Young’s lattice whose covering relations record the ways one may multiply by a single box in the appropriate new Pieri Rule. We obtain results on the homotopy type of these posets, in spite of these posets not being Cohen-Macaulay posets, motivated by the observation that the Möbius function appeared to be 0, 1 or -1 on each poset interval. To this end, we developed a new general procedure for transforming a poset edge labeling into a more convenient chain labeling; in our case this led to very well behaved discrete Morse functions, building upon the machinery developed by Babson and Hersh for constructing discrete Morse functions from lexicographic orders. (Received September 11, 2012)

1086-05-741 **Huimin Song, Hong-Jian Lai, Sun Lei and Ye Chen*** (chenye@math.wvu.edu), 320 Armstrong Hall, P.O. Box 6310, Morgantown, WV 26505. *r-hued Coloring K_4 -minor Free Graphs*.

For positive integers k and r , a (k, r) -coloring of a graph G is a proper k -coloring of the vertices such that every vertex of degree d is adjacent to vertices with at least $\min\{d, r\}$ different colors. The r -hued chromatic number, denoted by $\chi_r(G)$, is the smallest integer k for which a graph G has a (k, r) -coloring. For $r = 2$, χ_2 is known as the dynamic chromatic number. Let G be a K_4 -minor free graph. We proved that $\chi_r(G)$ is at most (i) $r + 3$ if $2 \leq r \leq 3$; or (ii) $\lfloor 3r/2 \rfloor + 1$ if $r \geq 4$. Examples are given to show the bounds can be attained. (Received September 25, 2012)

1086-05-763 **Soumya Bhoumik*** (sb781@msstate.edu), 109 Locksley Way, Apt # 125, Starkville, MS 39759, and **Edward Dobson and Joy Morris**. *Asymptotic Automorphism Groups of Circulant Graphs and Digraphs*. Preliminary report.

We show that almost all circulant graphs have automorphism groups as small as possible. Of the circulant graphs that do not have automorphism group as small as possible, we give some families of integers such that it is not true that almost all circulant graphs whose order lies in any one of these families, are normal. That almost all Cayley (di)graphs whose automorphism group is not as small as possible are normal was conjectured by the second author, so these results provide counterexamples to this conjecture. It is then shown that there is a “large” family of integers for which almost every circulant digraph whose order lies in this family and that does not have automorphism group as small as possible, is normal. We additionally explore the asymptotic behavior of the automorphism groups of circulant (di)graphs that are not normal, and show that no general conclusion can be obtained. (Received September 12, 2012)

1086-05-793 **Steven Klee** (klees@seattleu.edu), Department of Mathematics, Seattle University, Seattle, WA 98122, and **Isabella Novik*** (novik@math.washington.edu), Department of Mathematics, University of Washington, Seattle, WA 98195-4350. *From flag complexes to banner complexes*. Preliminary report.

Inspired by a recent work of Björner and Vorwerk, we introduce a notion of i -banner complexes: for various values of i these complexes interpolate between the class of flag complexes and the class of all simplicial complexes. We provide examples of simplicial spheres of an arbitrary dimension that are $(i + 1)$ -banner, but not i -banner. We then establish i -banner analogues of several theorems for flag complexes. For instance, we prove that (1) the codimension- $(i + j - 1)$ skeleton of an i -banner homology sphere Δ is $2(i + j)$ -Cohen–Macaulay for all $0 \leq j \leq \dim \Delta + 1 - i$, and that (2) for every i -banner simplicial complex Δ there exists a balanced complex Γ whose face numbers of dimension $i - 1$ and higher coincide with those of Δ . (Received September 12, 2012)

1086-05-804 **Arvind Ayyer, Steven Klee and Anne Schilling*** (anne@math.ucdavis.edu). *Combinatorial Markov chains on linear extensions*.

We consider generalizations of Schützenberger’s promotion operator on the set L of linear extensions of a finite poset of size n . This gives rise to a strongly connected graph on L . By assigning weights to the edges of the graph in two different ways, we study two Markov chains, both of which are irreducible. The stationary state of one gives rise to the uniform distribution, whereas the weights of the stationary state of the other has a nice product formula. This generalizes results by Hendricks on the Tsetlin library, which corresponds to the case when the poset is the anti-chain and hence $L = S_n$ is the full symmetric group. We also provide explicit eigenvalues of the transition matrix in general when the poset is a rooted forest. This is shown by proving that the associated monoid is R -trivial and then using Steinberg’s extension of Brown’s theory for Markov chains on left regular bands to R -trivial monoids. This is joint work with Arvind Ayyer and Steve Klee.

Time permitting we will also mention new models (sandpile and TOOM models), where the techniques of R -trivial monoids seem to work. This is based on joint work with Arvind Ayyer and Nicolas M. Thiéry. (Received September 13, 2012)

1086-05-822 **James Carraher** (s-jcarrah1@math.unl.edu), **Michael Ferrara** (michael.ferrara@ucdenver.edu), **Timothy Morris** (timothy.morris@ucdenver.edu) and **Michael Santana*** (santana@illinois.edu). *Pancyclicity of 4-Connected, Claw-Free, $N(i, j, k)$ -Free Graphs*. Preliminary report.

A graph G is said to be pancyclic if G contains cycles of all lengths from 3 to $|V(G)|$. Let $N(i, j, k)$ be the graph formed by associating paths of length i, j , and k , with distinct vertices of a triangle. We show that if G is 4-connected, claw-free, and $N(i, j, k)$ -free with $i + j + k = 6$ and $i, j, k \geq 1$, then G is pancyclic. This is best possible and extends a result of Gould, Luczak, and Pfender. In addition, our results complete a characterization of pairs of forbidden subgraphs that imply pancyclicity. (Received September 13, 2012)

1086-05-865 **Xinyu Sun*** (solaroflare@hotmail.com), 3550 Grandlake Blvd, #D205, Kenner, LA 70065. *A New Algorithm on Hypergeometric Summations and Recursions on Wigner's 6j-Symbols*. Preliminary report.

A new fast algorithm is developed to find recursions on sums of proper hypergeometric terms, which is based on Zeilberger's creative telescoping, but implements a method other than Gosper's algorithm. Using the algorithm, we find a sharp upper bound for the order of recursions. At the end, we show that when all the symbols in $6j$ -symbols problems are constant multiples of n , the resulting function always satisfy a recursion over n of order 2, regardless of the constants. (Received September 14, 2012)

1086-05-872 **Jonathan S. Sheperd*** (jsheperd@nd.edu). *Avoiding Colored Partitions of Two Elements*.

A k -colored partition of the ordered set $[n] := \{1, \dots, n\}$ consists of a partition of $[n]$ and an assignment of a color from $[k]$ to each element of $[n]$. A colored partition π avoids ρ if the partition component of π contains no copy of the partition component of ρ on which the color sequence is order-isomorphic to that of ρ . Here we expand upon the work of Goyt and Pudwell by counting the k -colored partitions of $[n]$ elements that avoid any set of colored partitions of 2 elements. (Received September 14, 2012)

1086-05-890 **Kristen Bartosz*** (bartoszk@onid.orst.edu), 704 SW 14th St., Apt 1, Corvallis, OR 97333. *Stack Sorting*. Preliminary report.

Sorting permutations with stacks was first introduced in the 1960s by Knuth. He proved that a permutation is one stack sortable if it avoids a 231-pattern. He also proved that the number of n -permutations that are one stack sortable is the Catalan Number C_n . This paper will investigate more closely the exact number of stack sorts needed for n -permutations based on different patterns. Along with the Catalan numbers, sequences of n -permutations that are x stack sortable with $n < 9$ will be shown. (Received September 15, 2012)

1086-05-894 **Samantha Pinella*** (s.pinella@sms.ed.ac.uk) and **Kristen Bartosz**. *Symmetric Difference Free Families*.

The symmetric difference of two subsets of $[n]$ contains all elements that are in exactly one of the subsets. We treat the symmetric difference as a binary operator and explore its properties, including the number of ways a subset of $[n]$ can be represented as the symmetric difference of other subsets of $[n]$. We use these properties to study symmetric difference free families. These are families of subsets that are Sidon; the symmetric difference of any two elements is not the same as the symmetric difference of another two elements. We present a greedy algorithm based lower bound and a pigeon-hole principle based upper bound on the size of families with this property. Finally, a model where we select subsets to be included in a family at a certain probability is utilized to see what probability is required for the Sidon property to hold, including what happens at the threshold. (Received September 15, 2012)

1086-05-898 **Yevgeniy Rudoy***, yrudoy@gmail.com. *An inductive approach to constructing Universal Cycles on $\left[\begin{smallmatrix} n \\ k \end{smallmatrix} \right]$* .

In this paper, we introduce a method of constructing Universal Cycles on sets by taking "sums" and "products" of smaller cycles. We demonstrate this new approach by proving that if there exist Universal Cycles on $\left[\begin{smallmatrix} 18 \\ 4 \end{smallmatrix} \right]$ and $\left[\begin{smallmatrix} 26 \\ 4 \end{smallmatrix} \right]$, there must exist a Universal Cycle on $\left[\begin{smallmatrix} n \\ 4 \end{smallmatrix} \right]$ for any integer $n \geq 18$ equivalent to 2 (mod 8). (Received September 15, 2012)

1086-05-904 **Jang Soo Kim*** (kimjs@math.umn.edu), 302 Vincent Hall, 206 Church St. SE, Minneapolis, MN 55455. *Moments of Askey-Wilson polynomials*.

Recently, Kim and Stanton found new formulas for the moment $\mu_n(a, b, c, d; q)$ of Askey-Wilson polynomials. They also found a nice combinatorial formula for the moment when $d = 0$. However, their proof was not combinatorial. In this talk I will explain a combinatorial way to compute the Askey-Wilson moment using an idea in the work of Ismail, Stanton, and Viennot in 1987. Then I will show a new and nicer (in a combinatorial sense) formula for the Askey-Wilson moment which reduces to the formula of Kim and Stanton when $d = 0$. Using this new formula we can prove a positivity conjecture of Kim and Stanton. This is joint work with Dennis Stanton. (Received September 15, 2012)

1086-05-905 **Samuel Francis Hopkins*** (samuefhopkins@gmail.com) and **Morgan Weiler** (mocowe@gmail.com). *Pattern avoidance in permutations on posets*.

We extend the concept of pattern avoidance in permutations on a totally ordered set to pattern avoidance in permutations on partially ordered sets. The number of permutations on P that avoid the pattern π is denoted

$Av_P(\pi)$. We extend a proof of Simion and Schmidt to show that $Av_P(123) \leq Av_P(132)$ for any poset P , and we exactly classify the posets for which equality holds. (Received September 15, 2012)

1086-05-941 **Lauren K. Williams*** (williams@math.berkeley.edu). *Cluster Algebras.*

Cluster algebras are commutative rings with a set of distinguished generators having a remarkable combinatorial structure. They were introduced by Fomin and Zelevinsky in 2000 in the context of representation theory, but have since appeared in many other contexts, from Poisson geometry to triangulations of surfaces and Teichmüller theory.

In this talk I will give a gentle introduction to cluster algebras and then sketch how the theory led to a solution of Zamolodchikov's periodicity conjecture in mathematical physics. (Received September 16, 2012)

1086-05-991 **Miklos Bona*** (bona@uf1.edu), Department of Mathematics, University of Florida, Gainesville, FL 32611-8105. *New upper bounds for permutations avoiding 1324 and other extremal patterns.*

We show that the number of permutations of length n avoiding the pattern 1324 is at most $(7 + 4\sqrt{3})^n$. Then we generalize our method to find upper bounds for permutations avoiding the pattern $q_k = 13254 \dots k(k-1)$ if k is odd and $q_k = 13254 \dots (k-1)(k-2)k$ if k is even. Our results, together with numerical evidence suggest that if q is any pattern of length k , then the number of permutations of length n avoiding q is at most $(2.25k^2)^n$.

Our proofs will be based on injective encodings of pattern-avoiding permutations by pairs of words over finite alphabets that avoid certain factors. (Received September 17, 2012)

1086-05-1015 **Benjamin Jerome Kraft*** (benkraft@mit.edu). *Diameters of groups generated by transposition trees.*

Let $G = \langle S \rangle$ be a group, and let Γ be its Cayley graph. Computing the diameter of Γ is a computationally hard problem which comes up in several contexts. Thus, it is useful to be able to compute bounds on the diameter of Cayley graphs. In Ganesan the case where S is a minimal set of transpositions which generate G is examined, and an algorithm to find an upper bound on the diameter of Γ without examining each permutation is exhibited. Expanding on this work, we give several new algorithms to compute upper bounds on the diameter of Γ , without examining individual elements of G . Some of the algorithms we give are computationally more efficient than Ganesan's; one is computationally similar but produces much tighter bounds in many cases. (Received September 19, 2012)

1086-05-1040 **Sachi Hashimoto*** (sachi@uchicago.edu). *Sharper Lower Bounds in the Maximum Degree and Diameter Bounded Subgraph Problem in the Mesh.*

The Maximum Degree and Diameter Bounded Subgraph Problem (MaxDDBS) asks: given a host graph G , a bound on maximum degree Δ , and a diameter D , what is the largest subgraph of the host graph with degree bounded by Δ and diameter bounded by D ? We investigate the problem when the host graph is k -dimensional mesh. We provide lower bounds for the size of the largest subgraph of the mesh satisfying MaxDDBS for all k and $\Delta \geq 4$ that agree with the known upper bounds up to the first two terms, and show that for $\Delta = 3$, the lower bounds are at least the same order of growth as the upper bounds. (Received September 18, 2012)

1086-05-1043 **Gerard D. Cohen***, cohen@enst.fr, and **Emanuela Fachini** and **Janos Korner**. *Connector families of graphs.*

For every pair of fixed natural numbers $k > l$ we consider families of subgraphs of the complete graph K_n such that each graph in the family has at least k connected components while the union of any two has at most l . We show that the cardinality of such a family is at most exponential in n and determine the exact exponential growth of the largest such families for every value of k and $l = 1$.

Let $C(k) = C(k, n)$ be the family of those subgraphs of K_n which have at least $k > 1$ connected components. We say that a family $G \subseteq C(k, n)$ is a *connector family* if the union of any two of its members is connected. We are interested in the largest cardinality of a connector family, asymptotically in n and as a function of k . Let D be the family of all the connected graphs. Let the largest cardinality of a connector family be $M(C(k, n), D)$. We have

Theorem

For every $k > 0$ the largest size $M(C(k, n), D)$ of a connector family is exponential in n and the asymptotic exponent is

$$\lim_{n \rightarrow \infty} \log \sqrt[n]{M(C(k, n), D)} = h\left(\frac{1}{k}\right),$$

where $h : [0, 1] \rightarrow [0, 1]$ is the binary entropy function. (Received September 18, 2012)

1086-05-1067 **Craig M. Timmons*** (ctimmons@ucsd.edu). *Ordered Turán Problems.*

In this talk we will discuss some ordered Turán problems for bipartite graphs. Let G be an n -vertex graph with vertex set $\{1, 2, \dots, n\}$ and view the vertices of G as being ordered in the obvious way. A *zig-zag* $K_{s,t}$ is a $K_{s,t}$ whose parts $A = \{n_1 < n_2 < \dots < n_s\}$ and $B = \{m_1 < m_2 < \dots < m_t\}$ satisfy the condition $n_s < m_1$. A *zig-zag* C_{2k} is an even cycle with $2k$ vertices where the vertices in one part of the bipartition precede all of those vertices in the other part. We will present upper bounds on the Turán numbers of zig-zag complete bipartite graphs and even cycles and compare these bounds to the ordinary Turán numbers of such graphs. We will also present constructions of zig-zag C_4 -free graphs with many edges. (Received September 18, 2012)

1086-05-1076 **Alice M Dean** and **Joan P Hutchinson*** (hutchinson@macalester.edu). *List-coloring on surfaces with varying list-sizes.* Preliminary report.

C. Thomassen proved that if the vertices of one face of an embedded planar graph have 3-lists and all other vertices have 5-lists, then the graph is list-colorable. We ask whether an analogous theorem holds for graphs embedded on surfaces of larger Euler genus. For $\epsilon > 0$, let $H(\epsilon) = \left\lfloor \frac{7 + \sqrt{24\epsilon + 1}}{2} \right\rfloor$. Thanks to Heawood, Ringel & Youngs, and Borodin it is known that every graph of Euler genus $\epsilon > 0$ can be $H(\epsilon)$ -list-colored, but possibly not with smaller lists. Suppose the vertices of one face of a graph embedded on a surface of Euler genus $\epsilon > 0$ have $(H(\epsilon) - 2)$ -lists and all other vertices have $H(\epsilon)$ -lists. Can the graph be list-colored? We prove that the answer is yes for an infinite number of surfaces provided the graph does not contain $K_{H(\epsilon)-1}$ with all vertices on the face with $(H(\epsilon) - 2)$ -lists, and we investigate the extent to which this result is true for all surfaces. The statement is always true when $H(\epsilon) - 2$ is replaced by $H(\epsilon) - 1$ and is not true when $H(\epsilon) - 2$ is replaced by 3. (Received September 19, 2012)

1086-05-1086 **Ben Bond*** (benbond@mit.edu). *EKR sets for large n and r .*

Let $\mathcal{A} \subset \binom{[n]}{r}$ be a compressed, intersecting family and let $X \subset [n]$. Let $\mathcal{A}(X) = \{A \in \mathcal{A} : A \cap X \neq \emptyset\}$ and $\mathcal{S}_{n,r} = \binom{[n]}{r}(\{1\})$. Motivated by the Erdős-Ko-Rado theorem, Borg asked for which $X \subset [2, n]$ do we have $|\mathcal{A}(X)| \leq |\mathcal{S}_{n,r}(X)|$ for all compressed, intersecting families \mathcal{A} ? We call X that satisfy this property *EKR*. Borg classified EKR sets X such that $|X| \geq r$. Barber classified X , with $|X| \leq r$, such that X is EKR for sufficiently large n , and asked how large n must be. We prove n is sufficiently large when n grows quadratically in r . In the case where \mathcal{A} has a maximal element, we are able to sharpen this bound to $n > \varphi^2 r$ implies $|\mathcal{A}(X)| \leq |\mathcal{S}_{n,r}(X)|$. (Received September 18, 2012)

1086-05-1116 **Linnea LaMon**, **Audrey Lee-St.John** and **Jessica Sidman*** (jsidman@mholyoke.edu), Department of Mathematics and Statistics, Mount Holyoke College, South Hadley, MA 01002. *Rigidity in CAD software: from algebra to combinatorics.* Preliminary report.

In classical rigidity theory, fixed-length bars are connected to each other at flexible joints, resulting in a system of algebraic equations representing distance constraints between points. The rigidity of such a “bar-and-joint” framework has been studied by passing to the infinitesimal setting where a generic combinatorial analysis is possible. Bar-and-joint rigidity in the plane has a combinatorial characterization due to Laman, but remains challenging to understand in dimension 3. However, the related problem of characterizing the rigidity of a framework in \mathbf{R}^n composed of full-dimensional rigid bodies connected by bars was solved in the 1980s by Tay and White and Whiteley. I will discuss a generalization of the theory of body-and-bar rigidity developed by Haller, Lee-St.John, et al, for structures arising in Computer-Aided Design software in which the set of allowed constraints is enlarged to include consideration of coincidences and angles between bodies. I will present constraint equations, the infinitesimal constraints, and a combinatorial analysis in 2 and 3 dimensions. This is joint work with Audrey Lee-St.John. (Received September 19, 2012)

1086-05-1125 **H. Kierstead** (kierstead@asu.edu), School of Math. Sciences and Statistic, Arizona State University, Tempe, AZ 85287, **A. Kostochka*** (kostochk@math.uiuc.edu), Dept. of Mathematics, 1409 W. Green St., Urbana, IL 61801, and **E. Yeager** (yeager2@illinois.edu), Dept. of Mathematics, 1409 W. Green St., Urbana, IL 61801. *A refinement of the Corrádi-Hajnal Theorem.* Preliminary report.

Corrádi and Hajnal proved in 1963 the conjecture by Erdős that if $n \geq 3k$, then every n -vertex graph G with minimum degree at least $2k$ contains k vertex-disjoint cycles. The restriction on the minimum degree is sharp.

We prove a Brooks-type result describing for $k \geq 3$ the extremal graphs for the theorem. Namely, we show that if $k \geq 3$ and G is a graph with $n \geq 3k$ vertices and minimum degree at least $2k - 1$ that has no k vertex-disjoint cycles, then either G has an independent set of size $n - 2k + 1$ or $n = 3k$ and the complement of G is the disjoint union of a copy of K_k and a copy of $K_{k,k}$.

We also consider extremal graphs for the Ore-type version of the Corrádi-Hajnal Theorem. (Received September 19, 2012)

1086-05-1130 **Jacob T Hughes*** (jthughes@math.ucsd.edu). *Random Lights Out Processes on Graphs.* Lights Out is a single player game on graph G . The game starts with a coloring of the vertices of G with two colors, 0 and 1. At each step, one vertex is toggled which switches the color of that vertex and all of its neighbors. The game is won when all vertices have color 0. We consider the stochastic process arising from toggling a sequence of random vertices. We demonstrate how the process can be viewed as a random walk on an associated state graph. We then find the eigenvalues of the state graph, and use them to bound the rate of convergence and hitting times. We show that the distribution of this random process converges to the uniform distribution and show the χ squared distance after t steps is less than e^{-c} for all $t > \frac{n}{2}(1 + \frac{1}{r_2})\log(r_2) + c$, where r_2 is the rank of the adjacency matrix of the state graph plus the identity matrix taken over \mathbb{Z}_2 . We also provide bounds on the average number of steps until this random process reaches the all 0 coloring that are asymptotically tight for many families of graphs. (Received September 22, 2012)

1086-05-1132 **Wayne Goddard, Douglas Rall and Kirsti Wash*** (kirstiw@clemson.edu), O-110
Martin Hall, Box 340975, Clemson, SC 29634. *Identifying Codes in the Product of Cliques.* An identifying code in a graph is a set having the property that the closed neighborhood of each vertex in the graph has a nonempty, distinct intersection with the set. The minimum cardinality of an identifying code in a graph G is denoted $\gamma^{ID}(G)$. In this talk, we focus on computing lower bounds of $\gamma^{ID}(G)$ where G is a product of cliques. In particular, we compute the exact value of $\gamma^{ID}(K_n \times K_m)$ and $\gamma^{ID}(K_n \square K_m)$ when $n \leq m$. (Received September 19, 2012)

1086-05-1144 **Bridget Tenner***, Department of Mathematical Sciences, DePaul University, 2320 North Kenmore Avenue, Chicago, IL 60614. *Barred and vincular pattern avoidance.* Two variations on classical pattern avoidance are barred pattern avoidance and vincular pattern avoidance. The former requires that a pattern be avoided unless it is part of a specified larger pattern, while the latter requires avoiding a pattern whose letters are subject to specified adjacency requirements. In this talk we will explore when these two notions coincide. (Received September 19, 2012)

1086-05-1151 **Tristram Bogart***, Cra. 1 No. 18A- 12, Bogota, Colombia, **Mark Contois**, ON , Canada, and **Joseph Gubeladze**, Department of Mathematics, San Francisco State University, Thornton Hall 937, 1600 Holloway Ave, San Francisco, CA 94132. *Hom polytopes and cones.*

Given two full-dimensional convex cones C and C' in vector spaces V and V' , the hom-cone is the set of linear maps from V to V' that take C into C' . With Mark Contois and Joseph Gubeladze, we provide a range of results and examples in the case that C and C' are graded polyhedral cones. (Taking slices of the cones, we equivalently consider affine maps between polytopes.) Velasco recently extended some of the results to general convex cones, including the important case of the cone of positive semidefinite matrices, and many open questions remain. (Received September 19, 2012)

1086-05-1164 **Miles Eli Jones*** (mej005@ucsd.edu), 9500 Gilman Dr. #0112, La Jolla, CA 92093. A *Bijection with Derangements.* Preliminary report.

Consider the following set of objects called filled circled brick tabloids of length n . Partition the set $\{1, \dots, n\}$ such that each part has cardinality greater than or equal to 2. Construct bricks that have lengths equal to the cardinality of each part. Arrange the bricks in any order and fill each bricks with the numbers from its corresponding part in increasing order. For each brick circle any number except for the last number.

Here is an example of a filled circled brick tabloid of length 12.

1	4	⑤	7	10	11	12	③	6	②	8	9
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I will discuss why this set of objects has the same cardinality as the set of derangements of length n and I will show a bijection between the two sets. With this bijection, I will show that manipulating the filled circled brick tabloids in certain ways leads to derangements that have no consecutive pattern matches in any cycles. (Received September 19, 2012)

1086-05-1201 **Jonathan Browder*** (jonathan.browder@aalto.fi), Aalto University, Department of Mathematics, P.O. Box 11100, FI-00076 Aalto, Finland. *Face numbers of Buchsbaum simplicial posets.* Preliminary report.

A (finite) poset P is simplicial if it has unique minimal element $\hat{0}$ and the property that for every $p \in P$, the interval $[\hat{0}, p]$ is a Boolean algebra. A simplicial poset is Buchsbaum if its order complex is Buchsbaum as a

simplicial complex (as occurs, for example, when P is the face poset of a simplicial cell decomposition of a manifold). Novik and Swartz gave a set of necessary conditions on the face vectors of Buchsbaum simplicial posets in terms of their Betti numbers, and conjectured that these conditions are also sufficient, and thus provide a complete characterization. In this talk we will present some partial progress towards this characterization, and discuss some crystallization techniques that may be of use. (Received September 20, 2012)

1086-05-1203 **Sergey Avgustinovich** and **Sergey Kitaev***, Depart. of Computer and Information Sciences, University of Strathclyde, Livingston Tower, 26 Richmond Street, Glasgow, G1 1XH, and **Alexandr Valyuzhenich**. *Crucial and bicrucial permutations with respect to arithmetic monotone patterns.*

An *arithmetic occurrence* of a pattern in a permutation is a subsequence of the permutation that is order isomorphic to the pattern and whose indices form an arithmetic progression. For example, in the permutation 6245371, there are two arithmetic occurrences of the pattern 123, namely 245 and 257. A permutation is (k, ℓ) -anti-monotone if it avoids arithmetically the patterns $12 \cdots k$ and $\ell(\ell - 1) \cdots 1$.

An *extension* of a permutation π of length n to the right (resp., left) is a permutation $\pi'x$ (resp., $x\pi'$) of length $n + 1$ such that $x \in \{1, 2, \dots, n + 1\}$ and π' is obtained from π by adding 1 to each letter that is more or equal to x . A permutation π is (k, ℓ) -*crucial* (resp. (k, ℓ) -*bicrucial*) if π is anti-monotone but any extension of π to the right (resp., and to the left) is not (k, ℓ) -anti-monotone. For example, the permutation 216453 is $(3, 3)$ -crucial, while the permutation 73418562 is $(3, 3)$ -bicrucial.

We are interested in the following questions in which we assume $k, \ell \geq 3$: Do there exist (k, ℓ) -(bi)crucial permutations? If so, what is the minimum length of such permutations? Do arbitrary long (k, ℓ) -(bi)crucial permutations exist? (Received September 20, 2012)

1086-05-1215 **Chris Berg*** (cberg@lacim.ca), **Franco Saliola** and **Luis Serrano**. *Pieri operators on the affine nil Coxeter algebra.*

In their paper, “Affine insertion and Pieri rules for the affine Grassmannian”, Lam, Lapointe, Morse and Shimozono develop combinatorics associated to the study of k -Schur functions, and introduce generalizations of k -Schur functions, which they call strong Schur functions. Together with Saliola and Serrano, we developed a theory of operators on the nil Coxeter algebra which utilize the combinatorics of Lam, Lapointe, Morse and Shimozono. The development of these operators have allowed us to give structure coefficients in various cases and have solved several conjectures relating to strong Schur functions. In my talk, I will outline the definition and basic properties of these operators and explain their role in proving the conjectures. (Received September 20, 2012)

1086-05-1267 **K. Brooks Reid*** (breid@csusm.edu), Department of Mathematics, California State University San Marcos, 333 S. Twin Oaks Valley Road, San Marcos, CA 92096-0001. *Equi-Distance Partitions in Graphs*. Preliminary report.

A company is interested in locating a distribution facility to supply clients with products that only can be delivered one at a time (because of, for example, weight, or size, or volatility). The company owns only two suitable delivery vehicles for this product, and wishes to make deliveries in such a way that the total distances traveled by each of the two delivery vehicles are as nearly equal as possible. Motivated by this situation, let x denote a vertex in a connected graph $G = (V, E)$. We show that there exists a partition of $V - x$ into two non-empty subsets A and B so that the sum of the distances between x and all vertices in A differs by at most 1 from the sum of the distances between x and all vertices in B . In some cases this gives rise to a proper 2-colorings of the graph G . Vertices for which this difference is zero make ideal locations for such distribution facilities. We also consider instances of graphs in which this difference is 0 for all vertices x in G and instances of graphs in which this difference is 1 for all vertices x in G . (Received September 20, 2012)

1086-05-1287 **Xiaofeng Gu*** (xgu@math.wvu.edu). *Edge-disjoint spanning trees and eigenvalues in graphs.*

Let $\lambda_1(G)$, $\lambda_2(G)$ and $\tau(G)$ denote the largest eigenvalue, the second largest eigenvalue and the maximum number of edge-disjoint spanning trees of a graph G , respectively. Motivated by a question of Seymour on the relationship between eigenvalues of a graph G and bounds of $\tau(G)$, Cioabă and Wong conjectured that for any integers $d, k \geq 2$ and a d -regular graph G , if $\lambda_2(G) < d - \frac{2k-1}{d+1}$, then $\tau(G) \geq k$. They proved the conjecture for $k = 2, 3$, and presented evidence for the cases when $k \geq 4$. Thus the conjecture remains open for $k \geq 4$. We propose a more general conjecture that for a graph G with minimum degree $\delta \geq 2k \geq 4$, if $\lambda_1(G) + \lambda_2(G) < 2\delta - \frac{2k-1}{\delta+1}$, then $\tau(G) \geq k$. We prove that for a graph G with minimum degree δ , each of the following holds.

- (i) For $k \in \{2, 3\}$, if $\delta \geq 2k$ and $\lambda_1(G) + \lambda_2(G) < 2\delta - \frac{2k-1}{\delta+1}$, then $\tau(G) \geq k$.
(ii) For $k \geq 4$, if $\delta \geq 2k$ and $\lambda_1(G) + \lambda_2(G) < 2\delta - \frac{3k-1}{\delta+1}$, then $\tau(G) \geq k$. In particular, for a d -regular graph G with $d \geq 2k \geq 4$, if $\lambda_2(G) < d - \frac{3k-1}{d+1}$, then $\tau(G) \geq k$. (Received September 20, 2012)

1086-05-1288 **Zoltán Füredi**, University of Illinois, Urbana, IL 61801, and **Tao Jiang*** (jiangt@muohio.edu), Miami University, Oxford, OH 45056. *Hypergraph Turan numbers of loose cycles and linear cycles*. Preliminary report.

Given a positive integer n and a family \mathcal{H} of r -graphs, the Turán number $ex_r(n, \mathcal{H})$ is the maximum number of edges in an r -graph on n vertices not containing any member of \mathcal{H} . An r -uniform loose cycle of length k consists of a cyclic list of r -sets A_1, A_2, \dots, A_k such that $A_i \cap A_j \neq \emptyset$ if and only if $i = j$ or i, j are consecutive modulo k . A loose cycle is linear if consecutive sets in the list intersect in precisely one element. Let C_k^r denote the family of r -uniform loose cycles of length k and let L_k^r denote the r -uniform linear cycle of length k . For fixed $r, k \geq 3$, Mubayi and Verstraëte conjectured that $ex_r(n, C_k^r) = \ell \binom{n-1}{r-1} + O(n^{r-2})$, where $\ell = \lfloor \frac{k-1}{2} \rfloor$. They proved the conjecture for all r when $k = 3$ or 4 .

We prove their conjecture for all $r \geq 4$ and $k \geq 3$ in a stronger form by establishing for all large n the exact value of $ex_r(n, C_k^r)$. We also characterize the unique extremal construction and establish stability. When $r \geq 5$, we also obtain exact results for linear cycles. The asymptotics follow from a more general result that we establish. Our main tool is the Delta system method. (Received September 20, 2012)

1086-05-1292 **Sami Assaf*** (shassaf@usc.edu), **Nantel Bergeron** and **Frank Sottile**. *Schubert times Schur*.

We present a nonnegative combinatorial rule for multiplying Schubert polynomials by Schur polynomials using the Grassmannian-Bruhat order of Bergeron and Sottile and the theory of dual equivalence graphs of Assaf. (Received September 20, 2012)

1086-05-1293 **Edward D. Kim*** (edward.d.kim@gmail.com). *Subset partition graphs and an approach to the Linear Hirsch conjecture*.

In this talk, we will consider topological and combinatorial approaches to relaxations of the Hirsch Conjecture. Combinatorial abstractions of the graphs of polyhedra are receiving renewed interest as an approach to the linear Hirsch and polynomial Hirsch conjectures, since Santos disproved the Hirsch conjecture, which was relevant in the theoretical worst-case running time of the simplex method for linear optimization. We will give a survey of several classical combinatorial abstractions for polyhedral graphs. Then we show how they fit into a more general framework, which leads to some variants of these earlier abstractions. This flexible framework is defined by combinatorial properties, with each collection of properties taken providing a variant for studying the diameters of polyhedral graphs. We present a variant which has superlinear diameter, which together with some combinatorial operations gives a concrete approach for disproving the linear Hirsch conjecture. (Received September 20, 2012)

1086-05-1304 **Yan Zhuang*** (yazhu001@mail.goucher.edu), Goucher College Post Office, 1021 Dulaney Valley Road, Baltimore, MD 21204. *The VC Dimension of Random Set Systems, Word Sets, and Permutation Sets*. Preliminary report.

Given a random set system R , we say that R shatters a subset S of $\{1, 2, \dots, n\}$ if $\forall T \subseteq S, \exists A \in R$ such that $A \cap S = T$. Furthermore, the VC dimension of a random set system R is defined as the cardinality of the smallest subset of $\{1, 2, \dots, n\}$ that cannot be shattered by R . Since a subset is simply a word on two characters, we examine random word sets, which encompass the theory of random set systems. We generate a random t -set of n -words (where t is a function of n) by picking each character of each word with uniform probability, and present a series of threshold functions for t that determine the VC dimension of the random word set with high probability as $n \rightarrow \infty$. We then extend our work to permutations. This is a joint project with Anant Godbole and Samantha Pinella. (Received September 21, 2012)

1086-05-1312 **David J. Marchette*** (dmarchette@gmail.com), Naval Surface Warfare Center, 18444 Frontage Rd., Suite 327, Dahlgren, VA 22448. *An Analysis of Systems Readiness Functions*. Preliminary report.

Systems engineers have recently been investigating the definition and utility of “system readiness functions” for the analysis and engineering of complex systems. From a mathematical viewpoint, these are functions on weighted, attributed graphs. In this talk I will discuss system readiness functions as invariants on weighted, attributed graphs, and define a set of axioms that these functions should satisfy, as well as some properties that an engineer might find desirable. I will show that the current approaches to system readiness functions in the literature do not satisfy the axioms. I will close with progress towards a proof of the following conjecture:

aside from the “trivial” functions minimum and maximum, there are no functions that satisfy the axioms. This essentially says that to determine the “readiness level” of a system one need only consider either the minimum or the maximum of the readiness levels of the components of the system. This would suggest that the approach to the analysis of complex systems through systems readiness functions is flawed. (Received September 21, 2012)

1086-05-1319 **Georgia Benkart*** (benkart@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, Madison, WI 53706, and **Tom Halverson** (halverson@macalester.edu), Department of Mathematics & Computer Science, Macalester College, St. Paul, MN 55105. *McKay Centralizer Algebras*.

The McKay correspondence establishes connections between finite subgroups of $SU(2)$ and affine simply-laced Lie algebras. This talk will focus on our work (some joint with J. Barnes) relating those objects to certain finite-dimensional associative algebras, their combinatorics and representations, and to walks on affine Dynkin diagrams. (Received September 21, 2012)

1086-05-1379 **Federico Ardila*** (federico@sfsu.edu) and **Marcelo Aguiar** (maguiar@math.tamu.edu). *The Hopf Monoid of Generalized Permutahedra*.

Aguiar and Mahajan’s “Hopf monoids in species” constitute a good framework for the study of Hopf-algebraic structures associated to combinatorial objects. After illustrating this definition with some examples, I will introduce the Hopf monoid of generalized permutahedra (polytopes which arise in many contexts in mathematics). Our main result is an explicit antipode formula for this Hopf monoid. By specializing this formula to various submonoids, we obtain new and old results about the Hopf algebras of graphs, matroids, posets, etc. and their enumerative properties. (Received September 21, 2012)

1086-05-1385 **Federico Ardila*** (federico@sfsu.edu). *The combinatorics of $CAT(0)$ cubical complexes and robotic motion planning*.

We say that a cubical complex X is “ $CAT(0)$ ” if it has non-positive curvature. $CAT(0)$ cubical complexes play an important role in pure mathematics (group theory) and in applications (phylogenetics, robot motion planning, etc.) In particular, when one studies the possible positions of a discrete robot, one often finds that they naturally form a $CAT(0)$ cube complex.

Gromov gave a remarkable topological/combinatorial characterization of $CAT(0)$ cube complexes. We give an alternative, purely combinatorial description of them. Using this description, we give an algorithm to construct the shortest path between two points. For many robots, we can use these tools to find the fastest way to move from one position to another one.

The talk will describe joint work with Tia Baker, Megan Owen, Seth Sullivant, and Rika Yatchak. (Received September 21, 2012)

1086-05-1390 **Ping Zhang*** (ping.zhang@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008. *Hamiltonian Walks in Graphs*.

In 1973 Goodman and Hedetniemi introduced the concept of a Hamiltonian walk in a connected graph, defined as a closed spanning walk of minimum length in the graph. During the 10-year period 1973-83, this concept received considerable attention. In 2003, we introduced an alternative way to look at this concept. This new approach brought renewed interest in this topic and has resulted in increased research on this subject. We discuss some recent results obtained in this area. (Received September 21, 2012)

1086-05-1404 **Jed Yang*** (jedyang@ucla.edu). *Undecidable tiling problems*.

Given a set of tiles (think polyominoes) and a region, can we cover the region by translated copies of the tiles without overlaps? This tileability question is undecidable in general and NP-complete for finite regions.

In this talk, we will focus on the decidability of infinite problems. This may involve infinite regions, such as tiling the complement of a finite shape in the plane by a fixed set of tiles. On the other hand, it could involve tiling a finite region from an infinite family, such as asking if a set of tiles can form a rectangle of unspecified side lengths. We will discuss these (both are undecidable) and others as time permits. (Received September 21, 2012)

1086-05-1405 **Igor Pak** and **Jed Yang*** (jedyang@ucla.edu). *Hard tiling problems with simple tiles*.

Given a set of tiles (think polyominoes) and a region, can we cover the region by translated copies of the tiles without overlaps? This tileability question is undecidable in general and NP-complete for finite regions.

In this talk, we will focus on the complexity of finite problems. Our goal is to describe some simple tiles where the tiling problem is still hard. In particular, there is a fixed set of rectangular tiles whose tileability problem

is NP-complete. If time permits, we will also discuss tilings in higher dimensions using generalized dominoes. (Received September 21, 2012)

1086-05-1409 **Mark Dukes*** (mark.dukes@strath.ac.uk), University of Strathclyde, United Kingdom, and **Yvan Le Borgne** (borgne@labri.fr), CNRS, LaBRI, University Bordeaux 1, Bordeaux, France. *Parallelogram polyominoes, the sandpile model on $K_{m,n}$ and a q, t -Narayana polynomial.*

In this talk I will highlight some results from a recent paper (arXiv:1208.0024) that was motivated by a correspondence between bivincular patterns and composition matrices. We classify recurrent configurations of the sandpile model on the complete bipartite graph $K_{m,n}$ in terms of polyominoes. A canonical toppling process on these recurrent states gives rise to a *bounce* path within the corresponding polyomino. This bounce path, in turn, gives rise to a polynomial that we call the q, t -Narayana polynomial. We discuss this q, t -Narayana polynomial and its relation to the well-known q, t -Catalan polynomial. The specialization to the original correspondence between bivincular patterns and a sub-collection of recurrent configurations will also be touched upon. (Received September 21, 2012)

1086-05-1424 **Dara Moazzami*** (dmoazzami@ut.ac.ir), University of tehran, College of Engineering, Faculty of Engineering Science, Enghlab st, Tehran, Iran, and **Davoud Jelodar** (jelodar@ut.ac.ir), Tehran, Iran. *Tenacity of cycle permutation graph.* Preliminary report.

Numerous networks as, for example, road networks, electrical networks and communication networks can be modeled by a graph. Many attempts have been made to determine how well such a network is "connected" or stated differently how much effort is required to break down communication in the system between at least some nodes.

Two well-known measure that indicate how "reliable" a graph is, are the "Tenacity" and "Edge-tenacity" of a graph.

The tenacity of a graph G , $T(G)$, is defined by $T(G) = \min\{\frac{|A| + \tau(G-A)}{\omega(G-A)}\}$, where the minimum is taken over all vertex cutset A of G . We define $G-A$ to be the graph induced by the vertices of $V-A$, $\tau(G-A)$ is the number of vertices in the largest component of the graph by $G-A$ and $\omega(G-A)$ is the number of components of $G-A$. A connected graph G is called T -tenacious if $|A| + \tau(G-A) \geq T\omega(G-A)$ holds for any subset A of vertices of G with $\omega(G-A) > 1$. In this paper we provided a good upper bound for tenacity of cycle permutation graphs. (Received September 21, 2012)

1086-05-1441 **Moa Apagodu***, mapagodu@vcu.edu. *New series representations for Jacobi's triple product identity and more via the q -Markov method.*

We derive new series representations for Jacobi's triple product identity, the q -binomial theorem, q -analogs of the exponential function, and more using the q -Markov WZ method. (Received September 22, 2012)

1086-05-1445 **William Y. C. Chen** and **Ae Ja Yee*** (yee@math.psu.edu), University Park, PA 16802, and **Albert J. W. Zhu**. *Euler's partition theorem with upper bounds on multiplicities.*

We revisit a theorem of Andrews on equivalent upper bound sequences of multiplicities, from which the Euler partition theorem on partitions into distinct parts and odd parts can be deduced. By employing Boulet's four parameter formulas for partitions, we obtain a unification of Bessenrodt's alternating sum refinement and Andrew's generalization of the Euler theorem. We also discuss another theorem with upper bounds on even part multiplicities. (Received September 22, 2012)

1086-05-1455 **Adriano M. Garsia*** (garsia@math.ucsd.edu), Mathematics Department, University of California San Diego, 9500 Gilman Drive, La Jolla, CA 92093. *Recent Progress on the Shuffle Conjecture.*

This is my yearly report on the progress towards the resolution of the Shuffle Conjecture and its ramifications in the Theory of Macdonald Polynomials Eigen-operators. New results and Conjectures obtained since the last Joint meeting will be the highlights of the talk. (Received September 22, 2012)

1086-05-1468 **Lara Bradford***, lb8436@bard.edu, and **Carly Matson**. *New Results on the Coxeter Group Structure of Lecture Hall Partitions.* Preliminary report.

Bousquet-Mélou and Eriksson interpreted lecture hall partitions in terms of the affine Coxeter group of type C. We extend this interpretation to affine type B. We also use this framework to study a related structure called the d-sequence that encodes the successive differences between parts of the lecture hall partitions. (Received September 22, 2012)

1086-05-1489 **Michael J Earnest*** (mearnest@g.hmc.edu), 340 E. Foothill Blvd, Claremont, CA 91711. *Longest Common Patterns of Random Permutations.*

Similar to the longest common subsequence of two words, which is a measure of similarity between words, the longest common pattern can be used to measure the similarity of permutations. Specifically, the longest common pattern of two permutations of $1, 2, \dots, n$ is found by writing the permutations in word form and finding the longest pair of subsequences from each permutation which have the same relative ordering. Our research has shown when two permutations of length n are chosen randomly, then the expected length of their LCP grows proportionally to $n^{\frac{2}{3}}$. In this talk, we demonstrate the proof of this fact, and discuss bounds on the concentration around the mean, as well as how to generalize this to multiple permutations. (Received September 22, 2012)

1086-05-1509 **Morgan Weiler*** (mocowe@gmail.com) and **Samuel Hopkins.** *Pattern Avoidance in Permutations on the Boolean Lattice.*

We extend the concept of pattern avoidance in permutations on a totally ordered set to pattern avoidance in permutations on partially ordered sets. We give asymptotically close bounds on the number of permutations on the Boolean lattice that avoid the pattern $\{1\}\{1, 2\}\{2\}$. (Received September 22, 2012)

1086-05-1519 **Ya-Chen Chen*** (ya-chen.chen@asu.edu), Sacramento, CA 95814. *Minimum $K(2,3)$ -Saturated Graphs.*

Let F be a graph. A graph is F -saturated if it has no F as a subgraph, but contains F after adding any new edge. The minimum number of edges in an F -saturated graph is $\text{sat}(n, F)$. An F -saturated graph on n vertices with $\text{sat}(n, F)$ edges is a $\text{sat}(n, F)$ -graph. Erdos, Hajnal, and Moon proved that the $\text{sat}(n, K(k))$ -graph is the join of $(n - k + 2)$ independent vertices to every vertex in a complete graph $K(k-2)$ on $(k-2)$ vertices.

Pikhurko obtained $\text{sat}(n, F)$ of the complete $(r+1)$ -partite graph $K(1, \dots, 1, t)$, as later did G. Chen, Faudree, and Gould. Let $K(2,3)$ be the complete bipartite graph whose partite sets have size 2 and 3. Pikhurko and Schmitt presented $K(2,3)$ -saturated graphs with $(2n - 3)$ edges and obtained a lower bound of $\text{sat}(n, K(2,3))$. Bohman, Fonoberova, and Pikhurko determined $\text{sat}(n, F)$ asymptotically for complete multipartite graph F as n tends to infinity and gave structural information about almost extremal F -saturated graphs. We prove their conjecture that $\text{sat}(n, K(2,3)) = 2n - 3$. (Received September 23, 2012)

1086-05-1538 **Alex Fink*** (arfink@ncsu.edu) and **Felipe Rincon** (e.f.rincon@warwick.ac.uk). *The tropical Stiefel map and hyperplane arrangements.* Preliminary report.

The Stiefel map is the map from a matrix to its vector of maximal minors, whose image is the Grassmannian in its Plücker embedding. Tropically, though, the image of the Stiefel map is not the whole Grassmannian, i.e. some Plücker vectors do not arise from matrices. The tropical Stiefel image is covered by a collection of affine patches related to the support sets of Sturmfels and Zelevinsky; there are implications for the combinatorics of tropical hyperplane arrangements. Time permitting, we may discuss the topology of the image. (Received September 23, 2012)

1086-05-1541 **Daniel W. Cranston, William B. Kinnersley, Suil O and Douglas B. West*** (west@math.uiuc.edu). *Game matching number of graphs.*

We study a competitive optimization version of $\alpha'(G)$, the maximum size of a matching in a graph G . Players alternate adding edges of G to a matching until it becomes a maximal matching. One player (Max) wants that matching to be large; the other (Min) wants it to be small. The resulting sizes under optimal play when Max or Min starts are denoted $\alpha'_g(G)$ and $\hat{\alpha}'_g(G)$, respectively. We show that always $|\alpha'_g(G) - \hat{\alpha}'_g(G)| \leq 1$. We obtain a sufficient condition for $\alpha'_g(G) = \alpha'(G)$ that is preserved under cartesian product. Always $\alpha'_g(G) \geq \frac{2}{3}\alpha'(G)$, with equality for many split graphs, while $\alpha'_g(G) \geq \frac{3}{4}\alpha'(G)$ when G is a forest. Whenever G is a 3-regular n -vertex connected graph, $\alpha'_g(G) \geq n/3$, and such graphs exist with $\alpha'_g(G) \leq 7n/18$. For an n -vertex path or cycle, the value is roughly $n/7$. (Received September 23, 2012)

1086-05-1565 **Andrew Berget*** (aberget@uw.edu). *Conjectures on some vector bundles associated to matroids.*

In this talk I will describe some vector bundles on toric varieties associated to matroids. The higher cohomology groups of these bundles are conjectured to vanish and I will discuss the motivation and implications of this. This is intended to be an expository talk. In particular, no familiarity with the relevant cohomology theory will be needed or assumed. (Received September 23, 2012)

1086-05-1575 **Anders Björner*** (bjorner@kth.se). *Interlacing of h -vectors for Schlegel diagrams.* Preliminary report.

A Schlegel $(d-1)$ -diagram is a polytopal subdivision of a $(d-1)$ -polytope, obtained by projecting the boundary complex of a d -polytope P onto one of its facets. It is used to investigate P by visualization in a lower dimension.

The toric h -vector $h = (h_0, h_1, \dots, h_d)$ is recursively defined for any $(d-1)$ -dimensional polytopal complex. We prove that the toric h -vector of a Schlegel $(d-1)$ -diagram satisfies

$$h_d \leq h_0 \leq h_{d-1} \leq h_1 \leq h_{d-2} \leq h_2 \leq \dots \leq h_{\lfloor d/2 \rfloor + 1} \leq h_{\lfloor d/2 \rfloor - 1} \leq h_{\lfloor d/2 \rfloor}$$

(Received September 23, 2012)

1086-05-1579 **John Wilmes*** (wilmesj@math.uchicago.edu). *The toppling ideal and its minimal free resolution.* Preliminary report.

The chip firing game offer a fascinating bridge between combinatorial and algebraic objects. For example, Baker and Norine developed a Riemann-Roch theory on graphs using chip firing, and Cori, Rossin, and Salvy gave a correspondence between bases for certain monomial ideals and G -parking functions of undirected graphs. At the intersection of these ideas is the *toppling ideal* of an undirected graph. In this talk, I will define the toppling ideal, discuss its relation to the chip firing game, and give an explicit combinatorial description of its minimal free resolution. The results are due to joint work with David Perkinson, and subsequent work with Madhusudan Manjunath and Frank-Olaf Schreyer. (Received September 23, 2012)

1086-05-1585 **Jessica E Ginepro*** (jessginepro@yahoo.com), 1215 Wilbraham Rd., Box 4316, Springfield, MA 01119. *Closed Formulas for Folding Some Cases of the Origami Miura Map Fold.*

Corrugation Folds are a way of folding paper into a repeated pattern that resembles corrugated cardboard. In this talk we will be dealing with a type of corrugation fold called the Herringbone Pattern, where each vertex in the crease pattern looks like a bird's foot, with two congruent obtuse angles and two congruent acute angles. An example of this is the Miura Map Fold. Every origami model is determined by its crease pattern, and all creases are either mountain creases or valley creases. Therefore, each crease pattern has a mountain valley assignment, but only some of these are valid, meaning possible to fold without tearing our paper. We let $H(m, n) =$ the number of valid mountain-valley assignments that will fold the $m \times n$ Miura Map Fold flat. We show that $H(2, n) = H(n, 2)$ and produce a recursive formula for this $2 \times n$ case, which leads to a closed formula. We will also discuss obstacles in extending these results to the $n \times 3$, $n \times 4$, etc. cases. This research conducted under the guidance of Thomas Hull at Western New England University. (Received September 23, 2012)

1086-05-1606 **Jessica C De Silva*** (jdesilva1@csustan.edu), **Gabriel D Dorfsman-Hopkins** (gabriel.d.dorfsman-hopkins.13@dartmouth.edu) and **Joseph T Pruitt** (j92pruitt@gmail.com). *Interval-Vector Polytopes.*

An interval vector is a $(0, 1)$ -vector where all the ones appear consecutively. Fixing a dimension, we take the convex hull of certain subsets of interval vectors to form polytopes with interesting properties. We present a number of classes of interval-vector polytopes and prove in increasing generality their volumes and f -vectors. Among these classes are n -dimensional polytopes whose volumes are the n^{th} Catalan number and another whose volumes are the even numbers and whose f -vectors mirror the Pascal 3-triangle. (Received September 23, 2012)

1086-05-1607 **Dorit S Hochbaum*** (hochbaum@ieor.berkeley.edu), Department of IEOR, UC Berkeley, Berkeley, CA 94720. *Markov Random Fields: Complexity, versatility and algorithms.*

Continuous models have been commonplace in image segmentation, denoising and smoothing are shown here to have discrete analogs as various special cases of MRF. Continuous techniques include PDE methods, variational methods, gradient iterative methods, eigenvectors techniques and heuristics for models that include total variations, Mumford Shah, level sets and others. The well known classical discrete optimization model of Markov Random Fields (MRF) is shown here to formulate these, and other, continuous models. MRF was shown to be efficiently solvable for convex penalty functions, and NP-hard for non-convex functions, with algorithms that are fastest possible, or within a logarithmic factor to being fastest possible (Hochbaum 2001). Therefore the discrete version of total variation, binary Mumford Shah and others, are solved optimally and efficiently with MRF algorithms. This provides substantial improvement over the use of continuous techniques, not only in running time, but also in quality of results. We describe here how the MRF framework model applies to these continuous models and thus solves efficiently many well studied image segmentation and denoising problems. This demonstrates the power of discrete techniques over that of continuous methods for these problems. (Received September 23, 2012)

1086-05-1624 **Janine LoBue*** (jlobue@ucsd.edu). *Permuted Basement Fillings, k -ary Trees, and Watermelons*. Preliminary report.

In this talk, I will enumerate combinatorial objects known as *permuted basement fillings* which generate the polynomials $\widehat{E}_\gamma^\sigma$ known to decompose the Schur functions. These permuted basement fillings, or PBFs, are fillings of certain diagrams with integer entries, generalizing the tableaux which generate the Schur functions. These objects were originally introduced by Mason, who has found that many of the nice algebraic properties of the Schur functions are maintained by the $\widehat{E}_\gamma^\sigma$ s. Not much work has been done, however, on enumerating the permuted basement fillings of a given shape. Unfortunately, there is no analogue of the hook formula for counting the number of PBFs of a given general shape. I will show that we are able to count PBFs of certain basic shapes, including rectangles. We will find that these objects, which have come to be a topic of study primarily because of their algebraic significance, also have connections to familiar combinatorial objects including k -ary trees, lattice paths, and watermelons. Additionally, we will begin to look at certain patterns and statistics in PBFs to find q -analogues of these enumerative results. (Received September 23, 2012)

1086-05-1630 **Matthias Beck** (mattbeck@sfsu.edu), Department of Mathematics, San Francisco State University, 1600 Holloway Ave, San Francisco, CA 94132, **Felix Breuer** (felix@fbreuer.de), Department of Mathematics, San Francisco State University, 1600 Holloway Avenue, San Francisco, CA 94132, and **Yvonne Suzanne Kemper*** (ykemper@math.ucdavis.edu), Mathematical Sciences Building, One Shields Avenue, University of California, Davis, Davis, CA 95616. *Colorful and Higher-Dimensional Extensions in Simplicial Complexes*. Preliminary report.

We give some recent results from our continuing study of nowhere-zero \mathbb{Z}_k flows on simplicial complexes. We examine in particular the case of convex- and PS-ear decomposable simplicial complexes, and the question of polynomiality of the flow quasipolynomial in this case, and present some telling examples and counterexamples. In addition, inspired by totally cyclic orientations on graphs, we present connections to colorful generalizations of classic theorems in geometric combinatorics. (Received September 23, 2012)

1086-05-1651 **Matt Katz*** (katz@math.psu.edu). *Quotient Diagrams of Partitions*.

In this talk, we will partially answer a question posed by James Propp as well as showing the current progress in fully answering the question. (Received September 23, 2012)

1086-05-1659 **Sun Kim*** (kim.1674@math.osu.edu) and **Ae Ja Yee**. *Partitions with parity and part difference conditions, and Bressoud's conjecture*.

George Andrews involved parity restrictions in the Rogers-Ramanujan-Gordon identities to obtain new partition identities, and one case of his identities is related to the Göllnitz-Gordon identities. We extend Andrews' partition function, and relate it with the generalized Göllnitz-Gordon identities. Also, we prove partial results of Bressoud's conjecture regarding the generalized Rogers-Ramanujan-Gordon identities. (Received September 23, 2012)

1086-05-1676 **Ameera N Chowdhury*** (chowdhury@math.ucla.edu). *The Manickam-Miklós-Singhi Conjecture for Small k* . Preliminary report.

For a positive integer k , let $f(k)$ be the minimum integer N such that for all $n \geq N$, every set of n real numbers with nonnegative sum has at least $\binom{n-1}{k-1}$ k -element subsets whose sum is also nonnegative. In 1988, Manickam, Miklós, and Singhi proved that $f(k)$ exists and conjectured that $f(k) \leq 4k$. We prove $f(3) = 11$, $f(4) \leq 20$, $f(5) \leq 33$, and $f(6) \leq 48$, which improves previous upper bounds in these cases. The last two bounds were obtained jointly with Stephen Hartke and Derrick Stolee. With more patience, our arguments could yield improved upper bounds on $f(k)$ for larger k . Moreover, we show how our method could potentially yield a quadratic upper bound on $f(k)$. We end by discussing the vector space analog of the Manickam-Miklós-Singhi conjecture, about which we know distressingly little. (Received September 24, 2012)

1086-05-1693 **Tyler Seacrest*** (t_seacrest@umwestern.edu), 710 S. Atlantic St., Dillon, MT 59725. *An Arc-Weighted Second Neighborhood Conjecture*.

Given a digraph D and vertex v , the set $N_i(v)$ consists of all vertices at distance exactly i in the forward direction from v . Seymour conjectured that every oriented simple graph contains a vertex v such that $|N_1(v)| \leq |N_2(v)|$. Seymour's conjecture has been verified in several special cases, most notably by Fisher for tournaments.

One extension of the conjecture that has been used in several papers is to consider vertex-weighted digraphs. In this talk we introduce a version of the conjecture for arc-weighted digraphs. We prove the conjecture for arc-weighted tournaments, strengthening Fisher's theorem. Our proof does not rely on Fisher's result, and can thus also be seen as an alternate proof of Fisher's theorem. (Received September 24, 2012)

1086-05-1718 **R. Christian** and **R. B. Richter*** (brichter@uwaterloo.ca). *Embedding a continuum in a surface.*

It is well-known, but not trivial, that there are only finitely many obstructions to the embeddability of a graph in a particular surface S . What about embeddability of a metric space in S ? For this and many related questions, the nicest spaces to consider are continua: compact, locally connected, metric spaces. In this case, we use graph-theoretic methods to show that there are finitely many obstructions to embeddability in S . In particular, we show that a continuum M embeds in a surface S if and only if M does not contain any of: a surface of smaller genus than S ; the disjoint union of S and a point; one particular graph-like space; or a finite graph that does not embed in S . (Received September 24, 2012)

1086-05-1724 **Lara K. Pudwell*** (lara.pudwell@valpo.edu) and **Daniel A. Daly**. *Pattern Avoidance in Rook Monoids*. Preliminary report.

The rook monoid, R_n , on $\{0, 1, \dots, n\}$ is the set of all $n \times n$ 0-1 matrices that contain at most one 1 in every row and column. As such rook monoids are generalizations of permutations. In this talk we introduce the notion of pattern avoidance in rook monoids and give several enumerative results. (Received September 24, 2012)

1086-05-1730 **David Clark*** (dcclark@umn.edu). *What makes finite geometry designs so special?*

Finite geometries provide some of the most highly structured examples of combinatorial designs. Hamada conjectured that, among all designs with the same parameters, finite geometry designs are the unique designs whose incidence matrices have the minimum p -rank. This turns out to be false – but only sometimes! In this talk, we will describe certain classes of designs which have highly geometric properties, including minimum p -rank, but which are not finite geometry designs. We will examine the geometric properties of these *pseudo-geometric designs*, focusing on the question: What specific structural properties are necessary in order to construct counterexamples to Hamada's conjecture? (Received September 24, 2012)

1086-05-1735 **Tina Helms** and **Heather Jordon*** (hdj@ams.org), 416 Fourth Street, Ann Arbor, MI 48103, and **Maggie Murray** and **Stephanie Zeppetello**. *Extended Skolem-type Difference Sets*.

A k -extended Skolem-type 5-tuple difference set of order t is a set of t 5-tuples $\{(d_{i,1}, d_{i,2}, d_{i,3}, d_{i,4}, d_{i,5}) \mid i = 1, 2, \dots, t\}$ such that $d_{i,1} + d_{i,2} + d_{i,3} + d_{i,4} + d_{i,5} = 0$ for $1 \leq i \leq t$ and $\{|d_{i,j}| \mid 1 \leq i \leq t, 1 \leq j \leq 5\} = \{1, 2, \dots, 5t+1\} \setminus \{k\}$. In this talk, we will give necessary and sufficient conditions on t and k for the existence of a k -extended Skolem-type 5-tuple difference set of order t . We will also consider hooked k -extended Skolem-type 5-tuple difference sets of order t and provide necessary and sufficient conditions for their existence. We will then show how these k -extended Skolem-type difference sets can be used to find decompositions of circulant and complete graphs of order n into 5-cycles, d -cycles, where d is a divisor of n , Hamilton cycles, and possibly a 1-factor. (Received September 24, 2012)

1086-05-1742 **Zoltan Furedi*** (z-furedi@illinois.edu), Rényi Institute of Mathematics, Budapest. *Trees and cycles in hypergraphs*. Preliminary report.

There are many interesting definitions of cycles and trees in hypergraphs. We call a sequence of distinct sets E_1, \dots, E_ℓ and vertices x_1, \dots, x_ℓ a *Berge cycle* of length ℓ if $x_i \in E_i$ and $x_i \in E_{i+1}$ (for $1 \leq i < \ell$) and $x_\ell \in E_1$ hold. We call it a *loose cycle* if the hyperedges have no triple intersection and $E_i \cap E_j \neq \emptyset$ implies $|i - j| = 1 \pmod{\ell}$. A loose cycle is *q-tight* if $|E_i \cap E_{i+1}| \leq q$ holds for consecutive pairs. The case $q = 1$ defines a *linear cycle*.

A sequence of distinct sets E_1, \dots, E_s is called a *forest* if for every edge E_i with $2 \leq i \leq s$ there exists an $1 \leq \alpha(i) < i$ such that E_α is the root edge of E_i , i.e., $E_i \setminus E_\alpha$ is disjoint from $\cup_{j < i} E_j$.

After a brief review we discuss some properties of trees in hypergraphs (a joint work with Tao Jiang) and also discuss the minimum size of hypergraphs avoiding certain cycles thus improve some recent results of Györi et al.

Many problems remain open. (Received September 24, 2012)

1086-05-1808 **Oscar Vega*** (ovega@csufresno.edu), Department of Mathematics, California State University, Fresno, Fresno, CA 93740-8001. *Pancyclicity in Finite Projective Planes*.

We define the embedding of a k -cycle into a finite projective plane π to be equivalent to $Levi(\pi)$ containing a $(2k)$ -cycle, where $Levi(\pi)$ is the plane's Levi graph. We then use geometric techniques to prove that $Levi(\pi)$ necessarily contains $(2k)$ -cycles, for all $3 \leq k \leq q^2 + q + 1$, and for all finite projective plane π .

This is a joint work with F. Lazebnik and K. Mellinger. (Received September 24, 2012)

1086-05-1810 **Allen J. Schwenk*** (schwenk@wmich.edu), Department of Mathematics, 1903 W Michigan Ave, Western Michigan University, Kalamazoo, MI 49008-5248. *Hamiltonian decompositions of line graphs of regular graphs. Allen Schwenk, Western Michigan University, Kalamazoo, MI 49008.*

Hamiltonian decompositions of line graphs of regular graphs. Allen Schwenk, Western Michigan University, Kalamazoo, MI 49008.

An r -regular graph has a line graph that is $2r-2$ regular. A Hamiltonian decomposition is a partition of these edges into $r-1$ Hamiltonian cycles. Can we determine which line graphs have Hamiltonian decompositions? The question is trivial for $r = 2$. We present a characterization for cubic graphs. For $r = 4$, we can guarantee a decomposition containing two Hamiltonian cycles and a third 2-regular component that may or may not be Hamiltonian. (Received September 24, 2012)

1086-05-1817 **Joshua C Ferrerra*** (jf3472@stu.armstrong.edu), 412 N Baldwin circle, Savannah, GA 31405. *Seeking lower bounds to Ramsey numbers using Dirichlet Difference Graphs.*

A Ramsey number $n = R(s, t)$ is the smallest integer such that if a graph G has order n , then either G contains a K_s sub-graph or \bar{G} contains a K_t sub-graph. With very few Ramsey numbers known, we seek to improve upon the known lower bounds for certain Ramsey numbers of the form $R(3, t)$ and $R(4, t)$. We do this by examining the properties of Dirichlet Character Difference Graphs. A Dirichlet character $\chi_n(k)$ for a prime p is equal to 1 if and only if k is an n^{th} residue of p . Dirichlet Character Difference Graphs are circulant graphs with the generators $\{k : \chi_n(k) = 1\}$. The maximum clique number of these graphs and their complements can give lower bounds to Ramsey numbers. (Received September 24, 2012)

1086-05-1826 **In-Jee Jeong** (in-jee_jeong@brown.edu) and **Gregg Musiker*** (musiker@math.umn.edu), Minneapolis, MN, and **Sicong Zhang** (sz2319@columbia.edu). *Brane Tilings and Cluster Algebras*. Preliminary report.

We discuss several results from enumerative combinatorics that are inspired by cluster algebras and brane tilings, from string theory. This is based on work from the 2011 and 2012 REU's in Combinatorics at University of Minnesota. (Received September 24, 2012)

1086-05-1831 **Henning Arnor Ulfarsson***, henningu@ru.is, and **Anders Claesson**. *GRIM: An algorithm for the discovery of generalized permutation patterns.*

Various properties of permutations (or objects in bijection with a subset of them) are captured by permutation patterns. Sometimes classical patterns suffice, e.g., the permutations avoiding 231 are the ones that require at most one pass through a stack to become sorted. Other properties require various generalizations of classical patterns, e.g.,

- (1) permutations that require at most two passes through a stack are the ones that avoid one classical pattern and one barred pattern;
- (2) forest-like permutations (corresponding to factorial Schubert varieties) are the permutations avoiding one classical pattern and one vincular pattern.

Mesh patterns provide a common generalization to many older pattern definitions such as barred, vincular, bivincular and interval patterns. GRIM is an algorithm we developed, that given a finite set of permutations, outputs a list of mesh patterns that the input avoids. The algorithm can successfully discover the descriptions mentioned above as well as many others.

In this talk we will discuss the implementation of the algorithm, new results it was used to find and extensions that are planned for it. (Received September 24, 2012)

1086-05-1847 **Holger Dell*** (holger@cs.wisc.edu), University of Wisconsin - Madison, Department of Computer Sciences, 1210 West Dayton Street, Madison, WI 53706-1685. *How Fast Can We Compute Combinatorial Problems such as the Permanent and the Tutte Polynomial?*

Ryser's famous inclusion-exclusion formula for the permanent is a major combinatorial insight, and it can be used to compute the permanent of any $(d \times d)$ -matrix in time $2^d \cdot \text{poly}(d)$. Conversely, I claim that if the permanent can be computed in time $1.99^d \cdot \text{poly}(d)$, then there is a new deep combinatorial insight into the structure of the permanent that we haven't found yet. Ruling out such an algorithm would philosophically say that it is Ryser's formula that really captures the complexity of the permanent.

In recent work, we proved that the permanent cannot be computed in time $2^{o(d)} \cdot \text{poly}(d)$ unless the exponential time hypothesis (ETH) fails, which is a reasonable assumption from computational complexity theory. In the talk, we will discuss this result and a similar result for the Tutte polynomial. Furthermore, we will explore whether it is possible to rule out algorithms for the permanent that run in time $1.99^d \cdot \text{poly}(d)$.

Talk based on joint work with Thore Husfeldt, Dániel Marx, Nina Taslaman, and Martin Wahlén. (Received September 24, 2012)

1086-05-1874 **Kwang Ju Choi*** (mathed96@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Bogdan Oporowski** (bogdan@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *The Cardinality of Minimal Not Near Planar Graphs*. Preliminary report.

In this work, we define *near planar* graphs G that are planar graphs or have an edge e such that $G \setminus e$ is planar. The class of near planar graphs are closed not under minors but under topological minor. In addition, we notice that we can make a trivial infinite series of planar graphs using an operation, namely parallel subdivision. We define a relationship \preceq between two graphs which is an extension of topological minor.

We define a minimal excluded class \mathcal{M} of near planar graphs under \preceq . We find that every member of \mathcal{M} except finite members is containing a Möbius ladder and is made by three blocks. (Received September 24, 2012)

1086-05-1883 **Monica Vazirani***, One Shields Ave, Davis, CA 95616, and **Kevin Walker**. *Representations of the affine BMW algebra*. Preliminary report.

The BMW algebra is a deformation of the Brauer algebra, and has the Hecke algebra of type A as a quotient. Its specializations play a role in types B, C, D akin to that of the symmetric group in Schur-Weyl duality. One can enlarge these algebras by a commutative subalgebra X to an affine, or annular, version. Unlike the affine Hecke algebra, the affine BMW algebra is not of finite rank as a right X -module, so induction functors are ill-behaved, and many of the classical Hecke-theoretic constructions of simple modules fail. However, the affine BMW algebra still has a nice class of X -semisimple, or calibrated, representations, that don't necessarily factor through the affine Hecke algebra. I will discuss Walker's TQFT-motivated 2-handle construction of the X -semisimple, or calibrated, representations of the affine BMW algebra. (Received September 24, 2012)

1086-05-1886 **Matthias Beck, Felix Breuer, Logan Godkin and Jeremy L. Martin*** (jmartin@math.ku.edu). *Enumerating cellular colorings, orientations, tensions and flows*. Preliminary report.

We study the enumeration of colorings, orientations, tensions and flows in an arbitrary pure CW-complex X . These objects are defined via linear algebra and specialize to familiar graph-theoretic definitions in the dimension-1 case. Our results include closed-form and deletion-contraction formulas for the numbers of colorings, tensions and flows of X with values in $\mathbb{Z}/k\mathbb{Z}$ or in $\{0, \pm 1, \dots, \pm k\}$; sufficient conditions for these functions to be polynomials in k ; and reciprocity theorems (i.e., combinatorial interpretations of their evaluations at negative values of k) inspired by Stanley's theorem on acyclic orientations. (Received September 24, 2012)

1086-05-1897 **Elizabeth Moseman*** (lizz.moseman@gmail.com). *Approximation of Multivariate Network Reliability*.

When a network is modelled by a graph and edges of the graph remain reliable with a given probability, the probability of the graph remaining connected is called the reliability of the network. This talk discusses one method of approximation in calculating the reliability of the network when the probability is allowed to vary by edge. This method is based on sequential importance sampling and exploits the similarities that arise since reliability is a special case of the Tutte polynomial. (Received September 24, 2012)

1086-05-1930 **M. D. Atkinson, Michael H. Albert and Vincent Vatter*** (vatter@ufl.edu). *Subclasses of the separable permutations*.

The separable permutations are those avoiding the patterns 2413 and 3142, or more informatively, those formed from the singleton permutation by repeated sums and skew sums. We prove that all subclasses of the separable permutations which do not contain $\text{Av}(231)$ or a symmetry of this class have rational generating functions. (Received September 24, 2012)

1086-05-1939 **Eric Rains and Monica Vazirani***, One Shields Ave, Davis, CA 95616. *Deformations of permutation representations of Coxeter groups*.

One can deform a Coxeter group W to its corresponding Hecke algebra $H(W)$ and a standard parabolic subgroup $W.I$ to a corresponding subalgebra $H(W.I)$. However, this is not the case for every subgroup U , even if U is conjugate parabolic. Sometimes one can still deform the associated permutation representation on cosets W/U .

Our motivating example is the action of the symmetric group on fixed-point-free involutions by conjugation.

In this talk, I'll define a larger class of "quasiparabolic" subgroups and more generally quasiparabolic W -sets, and show that they admit a flat deformation over $\mathbb{Z}[q]$ to a representation of $H(W)$. They also share other nice properties with W/W_I such as a shellable Bruhat order. (Received September 24, 2012)

1086-05-1945 **Emilie Hogan*** (emilie.hogan@pnnl.gov). *Applications of Graphs and Partial Orders at PNNL*. Preliminary report.

At Pacific Northwest National Laboratory I am studying knowledge systems (ontologies) for information discovery, observing computer networks to detect intruders and measure a level of risk for an attack, and modeling the power grid to aid engineers in predicting how it will evolve. In this talk I will describe the important role that discrete structures like graphs and partial orders play in each of these application areas. I will discuss how we are modeling the structures of interest, searching for certain types of substructures, and measuring distances within the structures. (Received September 24, 2012)

1086-05-2039 **Michael Severino***, michael.severino@umontana.edu. *Construction of Digraphs With Arbitrarily Large Girth and Chromatic Number*.

A natural digraph analogue of the graph-theoretic concept of an 'independent set' is that of an 'acyclic set', namely a set of vertices not spanning a directed cycle. Hence a digraph analogue of a graph coloring is a decomposition of the vertex set into acyclic sets. In the spirit of a famous theorem of P. Erdős [Graph Theory and Probability, Canadian J. Math. **11** (1959)], it was shown probabilistically in [D. Bokal. et al., The Circular Chromatic Number of a Digraph, J. Graph Theory **46** (2004), 227-240] that there exist digraphs with arbitrarily large girth and chromatic number. Here I give constructions of such digraphs. (Received September 24, 2012)

1086-05-2040 **Einar Steingrímsson*** (einar@alum.mit.edu), Computer and Information Sciences, University of Strathclyde, 26 Richmond Street, Glasgow, G11 6AY, United Kingdom. *The Permutation Poset, its Möbius Function and Topology*. Preliminary report.

The set of all permutations $\{1, 2, \dots, n\}$, for any n , forms a poset, where the relation is pattern containment. We study the Möbius function on the intervals of this poset. This seems to be hard for generic intervals. However, there is a computationally effective solution for the separable permutations, which are those that can be decomposed as sums and skew sums of singletons, equivalently, those permutations that avoid 2413 and 3142. There is also an effective formula for reducing the computation of the Möbius function on intervals of decomposable permutations to its computation for indecomposable ones. For indecomposable permutations, though, there are no general formulas yet, so that's the brick wall we are currently pounding on.

The Möbius function of an interval \mathcal{I} is equivalent to the Euler characteristic of the simplicial complex consisting of the chains of \mathcal{I} . We would like to understand more of the topology of these intervals. Here we know almost nothing, although there are indications that there may be many cases where the topology is nice and simple, such as being homotopy equivalent to a wedge of spheres.

Joint work with B. Tenner and with V. Jelínek, E. Jelínková and A. Burstein, and (in progress) with P. McNamara. (Received September 24, 2012)

1086-05-2049 **Anders Claesson*** (anders.claesson@strath.ac.uk), **Vít Jelínek** and **Einar Steingrímsson**. *Upper bounds for the Stanley-Wilf limit of 1324*.

Recently new upper bounds for the Stanley-Wilf limit (growth rate), L , for 1324-avoiding permutations have been given. Claesson, Jelínek and Steingrímsson showed that L is at most 16. This bound was later improved by Bóna who showed that L is less than 13.93. We shall discuss these results and a general conjecture about pattern avoiding permutations with relatively few inversions. If this conjecture is true then it follows that L is less than 13.002, which is one reason for why the conjecture is interesting. We feel that it is interesting in its own right as well. (Received September 24, 2012)

1086-05-2070 **Anant Godbole*** (godbolea@etsu.edu), **Sam Gutekunst**, **Vince Lyzinski** and **Yan Zhuang**. *Representation function of finite additive bases*.

In 1990, Erdős and Tetali found an infinite set of integers S such that for each $k \geq 2$ and sufficiently large n , $r_k(n) = \Theta(\log n)$, where $r_k(n)$ is the number of ways to represent n as the sum of k numbers in S . Recently, Godbole et al. considered a finite version of the problem and found a threshold probability p_n for the emergence of an *additive basis*, i.e. a set S' for which $r_k(n) \geq 1$. By slightly increasing p_n we show that for $j \in [\alpha n, (k - \alpha)n]$, $r_k(j) = \Theta(\log n)$ with high probability, thus providing a finite version of the Erdős and Tetali theorem. (Received September 25, 2012)

1086-05-2079 **Andrzej Czygrinow, H. A. Kierstead*** (hal.kierstead@me.com) and **Theodore Molla**. *On directed versions of the Corrádi-Hajnal Corollary*. Preliminary report.

Corrádi and Hajnal proved that every graph G on $3k$ vertices with $\delta(G) \geq 2k$ has a C_3 -factor. Wang proved that every directed graph G on $3k$ vertices with minimum total degree $\delta_t(G) := \min_{v \in V} (\deg^-(v) + \deg^+(v)) \geq 3(3k-1)/2$ has a DC_3 -factor, where DC_3 is the directed 3-cycle. The degree bound in Wang's result is tight. However, we prove that for all integers $a \geq 1$ and $b \geq 0$ with $a+b=k$, every directed graph G on $3k$ vertices with $\delta_t(G) \geq 4k-1$ has a factor consisting of a copies of TC_3 and b copies of graphs DC_3 , where TC_3 is the transitive tournament on three vertices. In particular, using $b=0$, there is a TC_3 -factor of G , and using $a=1$, it is possible to obtain a DC_3 -factor of G by reversing just one edge of G . All these results are phrased and proved more generally in terms of undirected multigraphs.

We conjecture that every directed graph G on $3k$ vertices with minimum semidegree

$$\delta_0(G) := \min_{v \in V} \min\{\deg^-(v), \deg^+(v)\} \geq 2k$$

has a DC_3 -factor, and prove that this is asymptotically correct. (Received September 24, 2012)

1086-05-2083 **Hemanshu Kaul*** (kaul@iit.edu), Department of Applied Math, 10 W 32 St., Chicago, IL 60616. *Temporal Scale for Dynamic Graphs*.

Graphs that arise in applications are inherently dynamic - they change with time. We think of a dynamic graph as a temporal stream of graphs (each denoting the interactions observed at a point in time) over a fixed set of vertices. The interactions that give rise to the dynamic graph can occur over a wide range of time scales - from seconds to years. However, such dynamic graphs are often aggregated (as a static graph) with no regard to the underlying (hidden) time scale. Or, even more importantly, when such data is analyzed it is difficult or impossible to find the correct time scale for aggregation of such a dynamic graph in order to find interesting patterns arising within this process. The mismatch between the inherent temporal scale of the underlying process and the scale at which the analysis is performed can obscure important insights and lead to wrong conclusions.

In this talk, we will give a short introduction to a formalization of this problem and to related fields of study. The focus will be on an axiomatic description for this problem, and computational/algorithmic approaches towards resolving it.

This is joint work with Rajmonda Sulo Caceres (UIC/ MIT Lincoln Lab) and Michael Pelsmajer (IIT). (Received September 24, 2012)

1086-05-2087 **Sarah Anderson** and **Jeong-Hyun Kang***, Department of Mathematics, University of West Georgia, Carrollton, GA, and **Hiren Maharaj**. *Codes with bounded distances, and their applications to distance graphs*.

It has been studied in coding theory to find the maximum size of binary codes of length n with minimum distance d under Hamming distance. In this talk, we study binary codes when the distance has a restriction of maximum distance as well. Various upper bounds including an exponential upper bound have been established using a result of Kabanjanskii-Levenstein and Jung's theorem in Combinatorial Geometry. We show applications of these coding theoretic results to a distance graph on n -dimensional integer grid to obtain various lower bounds on chromatic numbers. This is a joint work with S. Anderson and H. Maharaj. (Received September 24, 2012)

1086-05-2090 **Katy E Beeler*** (beelk11@wfu.edu), Department of Mathematics, Wake Forest University, Winston Salem, NC 27109, and **Kenneth S Berenhaut** (berenhks@wfu.edu), Department of Mathematics, Wake Forest University, Winston Salem, NC 27109. *Deterministic Walks with Choice*.

In this talk we consider deterministic movement on Cayley graphs, integrating local information, bounded memory and choice at nodes. The research is motivated by recent work on deterministic random walks and applications in multi-agent systems. Several results regarding passing tokens through toroidal grids are discussed, as well as some open questions. (Received September 24, 2012)

1086-05-2093 **Farbod Shokrieh*** (shokrieh@math.gatech.edu). *A tropical proof of the matrix-tree theorem*.

I will discuss a joint work with Matt Baker and Greg Kuperberg in which we give a geometric proof of the celebrated matrix-tree theorem for weighted graphs. (Received September 24, 2012)

1086-05-2100 **Eric Fairchild*** (fairchild1@gcc.edu), **Robin Mabe** and **Emma Polaski**.
Duoprisms: Polytope Numbers and Multiplication. Preliminary report.

Polytope numbers are a non-negative number sequence constructed from the geometry of a polytope. In this talk we will focus on the duoprism polytopes. A duoprism is a polytope resulting from the Cartesian product of two polytopes each of dimension two or higher. Using the ideas of H.K. Kim, we found the decomposition of simplex-simplex duoprism numbers into simplex numbers of the same dimension. This can be generalized so that if one knows the decomposition of two polytope numbers sequences into simplex numbers in the same dimensions, the decomposition of their duoprism polytope numbers is quickly determined. (Received September 24, 2012)

1086-05-2101 **Nancy Eaton**, **Adam Gilbert** and **A. M. Heissan*** (mia@math.uri.edu). *A coil G on n vertices is four-colorable*. Preliminary report.

Let G be a planar, inner-triangulated graph on n vertices whose depth-first search tree (DFS) is the path (v_1, v_2, \dots, v_n) . We call such a graph a *coil*. We define the *coil edges* to be the edges of the form (v_i, v_{i+1}) . All other edges of G are *crossing edges*. The *up-neighborhood* of v_i is the non-empty set of vertices with indices all less than $i - 1$. If m is the number of crossing edges and β is the number of up-neighborhoods in G , we show that G is four-colorable with at least $4 \cdot 3^{n-1} \left(\frac{2}{3}\right)^m \left(\frac{3}{4}\right)^{\beta-1}$ distinct colorings. (Received September 24, 2012)

1086-05-2102 **Robin Mabe*** (mabere1@gcc.edu), **Eric Fairchild** and **Emma Polaski**. *Expanded Simplices and Polytope Numbers*. Preliminary report.

Polytope numbers are a non-negative number sequence constructed from the geometry of a polytope. An expanded polytope is created by including all of the facets of the polynomial and its dual, each sharing appropriate vertices and filling in the gaps with the appropriate duoprisms. An expanded polytope is the Minkowski sum of the polytope and its dual. H.K. Kim has shown that any polytope number sequence can be decomposed into a sum of simplex number sequences in the same dimension. Using our earlier results on duoprism number sequences, we found the decomposition for the expanded simplices. Our proof uses generalized hypergeometric functions and several identities. (Received September 24, 2012)

1086-05-2106 **Emma Polaski*** (polaskiem1@gcc.edu), **Eric Fairchild** and **Robin Mabe**. *Higher Order Rectification: Polytope Numbers and Cutting*. Preliminary report.

Polytope numbers are a non-negative number sequence constructed from the geometry of a polytope. r -Rectification is the process of cutting of a vertex to the center of each r -dimensional cell connected to the vertex. We extend previous results to show a formula for the polytope numbers of an r -rectified simplex, by realizing the geometric process of cutting in an alternating summation of smaller simplex numbers in the same dimension. It is important to note that this realization of the geometric process in the polytope number sequences does not hold for rectifying other regular polytopes. (Received September 24, 2012)

1086-05-2133 **Daryl R DeFord*** (daryl.deford@email.wsu.edu). *Enumerating Distinct Chessboard Tilings*.

Counting the number of distinct colorings of various discrete objects, via Burnside's Lemma and Pólya Counting, is a traditional problem in combinatorics. Motivated by a method for proving upper bounds on the order of the minimal recurrence relations satisfied by a set of tiling instances, we address a related problem in a more general setting. Given an $m \times n$ chessboard and a fixed set of (possibly colored) tiles, how many distinct tilings exist, up to symmetry? More specifically, we are interested in the recurrent sequences formed by counting the number of distinct tilings of boards of size $(m \times 1), (m \times 2), (m \times 3), \dots$, for a fixed set of tiles and some natural number m .

We present explicit results and closed forms for several well-known classes of tiling problems, including tilings with dominoes and tilings with squares. Several of these cases have convenient representations in terms of the combinatorial Fibonacci numbers. Finally, we give a characterization of all $1 \times n$ tiling problems in terms of the generalized Fibonacci numbers and colored Fibonacci tilings. (Received September 25, 2012)

1086-05-2138 **Daphne Gold*** (dgold@smith.edu), Box 8890, Smith College, Northampton, MA 01063, and **Maneka Puligandla**, **Bayla Weick** and **Ruobing Zhang**. *Puzzling Graphs I*. Preliminary report.

Let G be a graph with chromatic number $\chi(G)$. A **puzzle** P on G is a partition of G into connected subgraphs. A **solution** to P is a coloring of the vertices of G using $1, 2, \dots, \chi(X)$, the chromatic number of G , such that adjacent vertices are assigned different numbers and so that the sum of the numbers assigned to each piece of the partition is the same. We say G is **puzzling** if there is a puzzle on G with a unique solution.

We investigate the concept of puzzling graphs, detailing classes of graphs that are puzzling and classes of graphs that aren't. (Received September 24, 2012)

1086-05-2143 **Tia Pilaroscia*** (tpilaroscia@smith.edu), Box 8928, Smith College, Northampton, MA 01063, and **Jize Zhang** and **Jasmine Osorio**. *Puzzling Graphs II*. Preliminary report.

Let P be a puzzle on a graph G with chromatic number $\chi(G)$. An **asolution** to P is a coloring of the vertices of G using $1, 2, \dots, \chi(X)$, the chromatic number of G such that adjacent vertices are assigned different numbers and so that the sums of the numbers assigned to the pieces of the partition are all different. We say G is **apuzzling** if there is a puzzle on G with a unique asolution.

We investigate the concept of apuzzling graphs, detailing classes of graphs that are apuzzling and classes of graphs that aren't. (Received September 24, 2012)

1086-05-2147 **Andrew Gainer-Dewar*** (againerdewar@carleton.edu), Carleton College, Department of Mathematics, 1 North College Street, Northfield, MN 55057. *Γ -species and the enumeration of k -trees*.

We extend Joyal's theory of combinatorial species to incorporate information about 'structural' group actions, yielding an object we term a ' Γ -species' and an associated enumerative theory. We then apply this theory and associated techniques to enumerate unlabeled k -trees, resolving questions left open by Moon, Beineke, and Pippert in 1969. (Received September 24, 2012)

1086-05-2153 **Irene Yuan Lo*** (ilo@princeton.edu), 1994 Frist Center, Princeton, NJ 08544. *Misere Play Hackenbush Flowers*.

We show that any disjunctive sum of Hackenbush Flowers G has as evil twin $G^* \in \{G, G + *\}$ such that the outcomes of G under normal and misère play are the same as the outcomes of G^* under misère and normal play respectively. This reduces a question of McKay, Milley and Nowakowski to understanding normal play Hackenbush Flowers. (Received September 24, 2012)

1086-05-2155 **Ilya Dumer*** (dumer@ee.ucr.edu) and **Olga Kapralova**. *Evaluating Boolean polynomials on Hamming spheres*.

Consider m -variate Boolean polynomials of degree r or less defined on all binary m -tuples and let these polynomials be evaluated on the m -tuples of a given Hamming weight b . From the coding perspective, this setting defines a shortened binary Reed-Muller code $RM(r, m)$ whose positions form a Hamming sphere of weight b in the binary m -dimensional space. In this talk, we specify some recursive properties of this single-layer construction and define its code parameters for arbitrary values of m, r , and b . For growing m , we also study some multi-layer constructions of low code rates. We then propose efficient decoding algorithms that achieve a vanishing decoding error probability if these codes are being used over the high-noise channels with a transition error probability that approaches $1/2$. (Received September 25, 2012)

1086-05-2165 **Ryan C Bunge** (rcbunge@ilstu.edu) and **Saad I El-Zanati** (saad@ilstu.edu), IL, and **Daniel Gibson*** (daniel.gibson@cune.org), **Jackelyn Nagel** (nagejack@my.dom.edu), **Benjamin Stanley** and **Allison Zale** (amzale@ilstu.edu). *On cyclic decompositions of $K_{n,n}$ minus a 1-factor into 2-regular graphs*.

Let G be a 2-regular bipartite graph with $n \equiv 0 \pmod{4}$ edges. We show that there exists a cyclic G -decomposition of $K_{n+1,n+1} - F$, where F is a 1-factor in $K_{n+1,n+1}$. (Received September 24, 2012)

1086-05-2183 **Saad El-Zanati** (saad@ilstu.edu), **Adam Hakes*** (ahakes@purdue.edu), **Joel Jeffries** (jaj21020@ucmo.edu), **Elizabeth Mastalio** (mastalie@uni.edu) and **Jordan Torf** (jntorf@ilstu.edu). *On decomposing λ -fold complete graphs into Stanton 4-cycles*.

Let G be a simple graph with edge set $E(G) = \{e_1, e_2, \dots, e_q\}$. A *Stanton G* is a graph SG obtained from G by replacing e_i with i parallel edges for $1 \leq i \leq q$. If $G \cong C_4$, then SG is called a *Stanton 4-cycle* and is denoted by SC_4 . For each integer $v \geq 4$ and each of the three non-isomorphic SC_4 , we find the smallest positive integer λ such that there exists an SC_4 -decomposition of the λ -fold complete graph on v vertices. (Received September 25, 2012)

1086-05-2216 **Ye Luo*** (luoye@math.gatech.edu), 686 Cherry Street, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *Tropical Convexity, Linear Systems, and General Reduced Divisors*.

We introduce a theory of tropical convexity to continuous functions over Borel measure spaces. We apply this theory to investigate the linear systems on metric graphs (tropical curves). In particular, we extend the

conventional notion of reduced divisors and propose a general one, which provides strong tools to study the properties of tropical convexity. (Received September 25, 2012)

1086-05-2236 **Saad I El-Zanati** (saad@ilstu.edu), **Marie Ermete*** (ermet1mn@gmail.com) and **James Hasty** (hastyj@bismarck.k12.il.us). *Tree decompositions of regular graphs and multigraphs*. Preliminary report.

Let H and G be graphs such that G is a subgraph of H . A G -decomposition of H is a set $\Delta = \{G_1, G_2, \dots, G_t\}$ of pairwise edge-disjoint subgraphs of H each of which is isomorphic to G and such that each edge of H occurs in exactly one G_i . Graham and Häggkvist have conjectured that every tree with n edges decomposes every $2n$ -regular graph. This conjecture has been confirmed for a small number of cases. If T is a tree with n edges and G is n -regular, then T may or may not decompose G . For a simple graph G , we let 2G denote the multigraph obtained by replacing each edge of G with two parallel edges. El-Zanati conjectures that if a T is a tree with n edges and G is an n -regular simple graph, then there exists a T -decomposition of 2G . We show that this conjecture holds true when T is a bistar and G is triangle free. (Received September 25, 2012)

1086-05-2248 **Abbas M Alhakim*** (aa145@aub.edu.lb), Bliss Street, P.O.Box: 11-0236, Beirut, Lebanon. *de Bruijn Sequences that Avoid Certain Patterns*. Preliminary report.

A recent technique to generate de Bruijn sequences is through the use of preference tables. These are minimal sets of rules that set priorities for digits to be appended one at a time so that the final sequence is de Bruijn, i.e. it does not miss any pattern of some fixed length. In this talk, we present minimal preference rules that generate sequences which are almost de Bruijn sequences. In other words, these are de Bruijn sequences that avoid particular sets of patterns.

We present results that characterize preference tables which produce such pattern avoiding de Bruijn sequences. (Received September 25, 2012)

1086-05-2263 **Christopher R. H. Hanusa** and **Brant C. Jones*** (jones3bc@jmu.edu). *Abacus models in affine Weyl groups*.

We introduce abacus diagrams that describe minimal length coset representatives in affine Weyl groups of types B, C, and D. These diagrams extend a construction of James for the symmetric group, and encode generalized core partitions that can be used to detect Bruhat relations. As an application, we enumerate the lecture hall partitions of Bousquet-Mélou and Eriksson. (Received September 25, 2012)

1086-05-2310 **Matt Davis**, **Michael Orrison** and **Francis Edward Su*** (su@math.hmc.edu), Department of Mathematics, Harvey Mudd College, 301 Platt Blvd, Claremont, CA 91711. *Voting for Committees*.

We examine the following voting situation. A committee of k people is to be formed from a pool of n candidates. The voters selecting the committee will submit a list of j candidates that they would prefer to be on the committee. We assume that $j \leq k \leq n$. For a chosen committee, a given voter is said to be *satisfied* by that committee if her submitted list of j candidates is a subset of that committee. We examine how popular is the most popular committee, i.e., we show there is always a committee that satisfies a certain fraction of the voters and examine what characteristics of the voter data will increase that fraction. (Received September 25, 2012)

1086-05-2316 **Mary K. Flagg*** (mflagg@math.uh.edu), Department of Mathematics, University of Houston, 641 Philip Guthrie Hoffman Hall, Houston, TX 77204-3008. *Using graph techniques to understand a nonsplit mixed p -adic module*. Preliminary report.

For a prime p , let J_p be the ring of p -adic integers. A module over J_p is a local abelian group. W. May proved that a mixed module of finite torsion-free rank over J_p is determined by its endomorphism ring. The author has shown that in the case of reduced modules with unbounded torsion submodules the Jacobson radical of the endomorphism ring of a module of finite torsion-free rank is sufficient to determine the isomorphism class of the module. The question that this research leads to for a mixed module is how the endomorphisms reflect or do not reflect the structure of the extension of the torsion module by a torsion-free module. How are the torsion submodule and the torsion-free elements intertwined? In hopes of understanding this connection better, the author will survey some of the graphical techniques used to describe groups. Also, graphs of the endomorphism ring and automorphism group of a mixed abelian group will be examined for clues to the connection between torsion and torsion-free elements. (Received September 25, 2012)

- 1086-05-2333 **Ji Young Choi*** (jychoi@ship.edu), 1871 Old Main Dr, Dept of Math, Shippensburg University, Shippensburg, PA 17257, and **Doug Ensley** (deensley@ship.edu). *Row reducing the Matrix of m -Generalized Combinations*. Preliminary report.

The number of ways to choose k elements from an n set allowed m repetitions is called the (n, k) -th m -generalized combination. This talk will show how the row echelon form of a matrix consisting of m -generalized combinations can be related to a matrix of $(m - 1)$ -generalized combinations. (Received September 25, 2012)

- 1086-05-2345 **Nathan H Reff*** (reff@alfred.edu), Department of Mathematics, Alfred University, Alfred, NY 14802. *Oriented Gain Graphs, Line Graphs and Eigenvalues*. Preliminary report.

A gain graph is a graph where each orientation of an edge is given a group element, which is the inverse of the group element assigned to the opposite orientation. We define line graphs of gain graphs and study some matrix properties of complex unit gain graphs. As with graphs and signed graphs, there is a relationship between the incidence matrix of a complex unit gain graph and the adjacency matrix of the line graph. The line graph of a gain graph is defined using oriented gain graphs, a new structure that generalizes Zaslavsky's oriented signed graphs and their line graphs. (Received September 25, 2012)

- 1086-05-2353 **Art M. Duval*** (artduval@math.utep.edu), **Caroline J. Klivans** (caroline_klivans@brown.edu) and **Jeremy L. Martin** (jmartin@math.ku.edu). *Max flow min cut in higher dimensions*. Preliminary report.

In previous work, we used matroid theory to extend the construction of cut and flow spaces of a graph to cell complexes of arbitrary dimension. Here we use these spaces to generalize the well-known max flow min cut theorem from graphs to cell complexes. Specifically, the maximum flow on a designated codimension-1 homology cycle equals the value of a minimum cut (a cocircuit in the cellular matroid) containing that cycle. (Received September 25, 2012)

- 1086-05-2378 **Sami Assaf*** (shassaf@usc.edu) and **David Speyer**. *Stable Schur functions*.

The Kronecker coefficients give the multiplicities for the irreducible decomposition of the (inner) tensor product of two \mathfrak{S}_n -modules. If one takes two arbitrary partitions and inserts a large number at the beginning so that the two partitions are now of the same size, then the multiplicities that appear eventually stabilize as the size of the first part increases. We present a new basis for symmetric functions whose structure constants are precisely these stable Kronecker coefficients. (Received September 25, 2012)

- 1086-05-2421 **Fan Chung*** (fan@ucsd.edu), 1555 Coast Walk, La Jolla, CA 92037. *Recent results and problems in spectral graph theory*.

We will discuss some recent developments in spectral graph theory and mention a number of results and problems on random walks on directed graphs, vertex and edge ranking, interlacing theorems, partition and clustering, among others. (Received September 25, 2012)

- 1086-05-2452 **Suil O*** (so@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23185, and **Douglas B West**. *The Chinese Postman Problem in regular graphs of odd degree*. Preliminary report.

The Chinese Postman Problem in a multigraph is the problem of finding a shortest closed walk traversing all the edges. In a $(2r + 1)$ -regular graph, the problem is equivalent to finding a smallest spanning subgraph in which all vertices have odd degree. In 1994, Kotstochka and Tulai established a sharp upper bound for the solution. For a 3-regular (multi-) graph with n vertices, we give a simple proof of the bound. We characterize the graphs where equality holds. (Received September 25, 2012)

- 1086-05-2480 **Alessandra K Graf*** (ag668@nau.edu). *A New Graceful Labeling for Pendant Graphs*.

A graceful labeling of a graph G with q edges is an injective assignment of labels from $\{0, 1, \dots, q\}$ to the vertices of G such that when each edge is assigned the absolute value of the difference of the vertex labels it connects, the resulting edge labels are distinct. A labeling of the first kind for coronas $C_n \odot K_1$ occurs when vertex labels 0 and $q = 2n$ are assigned to adjacent vertices of the n -gon. A labeling of the second kind occurs when $q = 2n$ is assigned to a pendant vertex. Previous research has shown that all coronas $C_n \odot K_1$ have a graceful labeling of the second kind. In this presentation we will show that all coronas $C_n \odot K_1$ with $n \equiv 3, 4 \pmod{8}$ also have a graceful labeling of the first kind. (Received September 25, 2012)

1086-05-2526 **Sean P Haler*** (seanhailer@gmail.com). *Packing Four Copies of a Tree into a Complete Graph.*

A tree T of order n is k -placeable if there exists k edge-disjoint copies of T in K_n , this is also known as a k -packing of T into K_n . Previous work has characterized all trees that are k -placeable for $k \leq 3$. Here those results are extended and a complete characterization of all trees that are k -placeable is given for $k = 4$. (Received September 25, 2012)

1086-05-2589 **Curtis Clark*** (cucclark@morehouse.edu), Morehouse College, Atlanta, GA 30314. *On 1 - 2 Graph Achievement Games.* Preliminary report.

Let F be a graph with no isolated vertices. The 1 - 2 F -achievement game on the complete graph K_n is described as follows. Player A first colors one edge of K_n green. Then player B colors two different edges of K_n red. They continue alternately coloring the edges with player A coloring one edge and player B coloring two edges. The graph F is achievable on K_n if player A can make a copy of F in his color. The minimum n such that F is achievable on K_n is the 1 - 2 achievement number of F , $a_{1-2}(F)$. The 1-2 move number of F is the least number of edges needed by player A to make F on the complete graph with $a_{1-2}(F)$ vertices. We determine the 1 - 2 achievement numbers and move numbers for graphs with less than or equal to four vertices, paths, and cycles. (Received September 25, 2012)

1086-05-2593 **Thomas Langley*** (langley@rose-hulman.edu). *Block transpositions, scrambling numbers, and commutativity.* Preliminary report.

We view the equation $ab = ba$ in a finite group as a special case of the equation $a_1 a_2 \cdots a_n = (a_1 a_2 \cdots a_n)^\sigma$ where the right hand side represents a reordering of the product by a permutation σ on n symbols. Investigating solutions to the general case leads to a generalization of the probability that two elements in a finite group commute, and spawns a discussion of scrambling numbers, derangements, and factoring permutations into generalized block transpositions. (Received September 25, 2012)

1086-05-2598 **Daniel Schaal*** (daniel.schaal@sdsstate.edu) and **Corey Vorland**. *Rado Numbers for a Linear Inequality.*

In 1916, I. Schur proved the following theorem: For every integer t greater than or equal to 2, there exists a least integer $n = S(t)$ such that for every coloring of the integers in the set $1, 2, \dots, n$ with t colors there exists a monochromatic solution to $x + y = z$. The integers $S(t)$ are called Schur numbers and are known only for $t = 2$, $t = 3$ and $t = 4$. R. Rado, who was a student of Schur, found necessary and sufficient conditions to determine if an arbitrary linear equation admits a monochromatic solution for every coloring of the natural numbers with a finite number of colors. Let L represent a linear equation or inequality and let t be an integer greater than or equal to 2. The least integer n , provided that it exists, such that for every coloring of the integers in the set $1, 2, \dots, n$ with t colors there exists a monochromatic solution to L is called the t -color Rado number for L . If such an integer n does not exist, then the t -color Rado number for L is infinite. In this talk we will consider a family of linear inequalities for which the exact 2-color Rado numbers have recently been determined. We will also present some open problems and discuss the general direction of research in this area. (Received September 25, 2012)

1086-05-2606 **Apoorva Khare*** (khare@stanford.edu), Departments of Mathematics and Statistics, Stanford University, 390 Serra Mall, Stanford, CA 94305, and **Bala Rajaratnam** (brajarat@stanford.edu). *A novel approach to analyzing graphons.*

Limits of dense graph sequences, also called graphons, have recently been the subject of enormous attention because of their applications to large networks, their evolution, and analysis. In particular, Lovasz and his collaborators (Borgs, Chayes, and so on), Diaconis, Tao, Varadhan, and their coauthors have published many insightful papers on the subject, which discuss graph limits, subgraph sampling, testable parameters, and so on. We present the results of ongoing work, in which we have been able to significantly extend many of the most important results involving the space of graphons, their limiting properties, and characterization of various classes of functions. We then demonstrate how our methods can be applied to other settings involving graphs. (Received September 25, 2012)

1086-05-2620 **Henry Cohn*** (cohn@microsoft.com), One Memorial Drive, Cambridge, MA 02142, and **Yufei Zhao**. *The physics of error-correcting codes.*

In this talk, we'll explore how discrete models of physics shed light on error-correcting codes. The most remarkable codes are those that are universally optimal, in the sense of minimizing a broad class of energy functions. This corresponds to optimality of the binomial moments of the distance enumerator, which has been studied by Ashikhmin and Barg, and we extend their theory. We show many parallels with continuous physics, but some

noteworthy differences: for example, whenever linear programming bounds prove that a code is universally optimal, removing any one codeword always yields another universally optimal code. (Received September 25, 2012)

1086-05-2626 **James Michael Shook*** (james.shook@nist.gov), 100 Bureau Drive, Stop 8910, Gaithersburg, MD 20899, and **Brian Cloteaux, Elizabeth Moseman and M Drew LaMar.** *Threshold Digraphs.*

Graphs or digraphs whose degree sequences have a unique labelled realization are called threshold. From this starting point, we show several equivalent characterizations of threshold digraphs. These characterizations include a constructive method and an algebraic characterization that threshold digraphs are precisely those digraphs whose degree sequences satisfy the Fulkerson inequalities as equalities. (Received September 25, 2012)

1086-05-2628 **Dominique Guillot, Alfred O Hero, Brett Naul and Bala Rajaratnam*** (brajarat@stanford.edu), Department of Statistics, Stanford University, Stanford, CA 94305. *Regularization of positive definite matrices: connections between algebra, graph theory and statistics.*

Positive definite (p.d.) matrices arise naturally in many areas within mathematics and also feature extensively in scientific applications. In modern high-dimensional applications, a common approach to finding sparse positive definite matrices is to threshold their small off-diagonal elements. This thresholding, sometimes referred to as hard-thresholding, sets small elements to zero. Thresholding has the attractive property that the resulting matrices are sparse, and are thus easier to interpret and work with. In many applications, it is often required, and thus implicitly assumed, that thresholded matrices retain positive definiteness. We will formally investigate the algebraic properties of positive definite matrices which are thresholded. Some interesting and unexpected results will be presented. If time permits, probabilistic properties of thresholded positive definite matrices and connections to optimization will also be discussed. (Received September 25, 2012)

1086-05-2681 **Noah Williams*** (williann@uwec.edu), 5520 Woodcrest Highlands Rd., Eau Claire, WI 54701. *The Deletion-Insertion Model Applied to the Genome Rearrangement Problem.* Preliminary report.

Many mathematical models have been developed to help solve the genome rearrangement problem, whose goal is to find the optimal sequence of mutations that transforms one genome into another. However, few of these representations isolate situations in which deletions and insertions are the primary mutations that occur. We created the Deletion-Insertion model, which considers genome rearrangement exclusively by deletions and insertions, in order to provide bioinformaticians with a tool for studying diseases, like Neurofibromatosis, that can develop as the result of a single deletion or insertion within a chromosome. In this research, we strive to strengthen our model by developing an algorithm for the rearrangement of one genome into another using the fewest possible number of deletions and insertions. Additionally, we analyze the efficiency of several algorithms that compute an upper bound for this optimized distance. Our results contribute to the understanding of mutation-based diseases and of the evolutionary relationships that exist between organisms and their biological ancestors. (Received September 25, 2012)

1086-05-2682 **Anton Dochtermann*** (anton@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33146. *Topological methods in combinatorial commutative algebra.*

We survey some new topological/geometric methods of studying monomial and binomial ideals arising from graphs and other combinatorial objects. These include cellular resolutions arising from algebraic mapping cones, deformations of associahedra and other polytopes via algebraic discrete Morse theory, as well as the encoding of syzygies via graphical hyperplane arrangements. These methods provide a unifying setting for some existing constructions from the literature and also lead to new results. Parts of this represent joint work with Fatemeh Mohammadi and with Raman Sanyal. (Received September 25, 2012)

1086-05-2684 **Bonnie C. Jacob*** (bcjntm@rit.edu). *A generalization of optimality of vertex rankings on infinite graphs.*

Given a graph G and a non-negative integer a , a function $f : V(G) \rightarrow \{a, a+1, \dots, b\}$ is an $[a, b]$ -ranking of G if for $u, v \in V(G)$, $f(u) = f(v)$ implies that every uv path contains a vertex w such that $f(w) > f(u)$. That is, f is an $[a, b]$ -ranking of G if and only if the function defined by $g(v) = f(v) - a + 1$ is a k -ranking of G .

Conventionally, the optimality of a vertex k -ranking on a graph was evaluated based on the l_∞ norm of the vertex labels appearing in the ranking. However, by looking at $[a, b]$ -rankings — which generalize k -rankings — and considering more general notions of optimality such as the l_p norm for any $p \in [1, \infty)$, we are able to

produce interesting results on the optimality of vertex rankings on infinite graphs. (Received September 25, 2012)

1086-05-2691 **Jobby Jacob*** (jxjsma@rit.edu). *Rank number of some graph Cartesian products.*

A k -ranking of a graph G is a function $f : V(G) \rightarrow \{1, 2, \dots, k\}$ such that if $f(u) = f(v)$ then every $u - v$ path contains a vertex w such that $f(w) > f(u)$. The rank number of G , denoted by $\chi_r(G)$, is the minimum k such that a k -ranking exists for G . Given a graph G and a positive integer t , deciding if $\chi_r(G) \leq t$ is NP-Complete. However, rank numbers of various classes of graphs have been established. We will discuss properties of k -rankings of some graph Cartesian products, along with the rank numbers of some of these graphs. (Received September 25, 2012)

1086-05-2753 **Jessica Striker*** (jessica@math.umn.edu) and **Nathan Williams** (will3089@umn.edu).

Promotion and rowmotion: Part 1/2. Preliminary report.

We study toggle group actions and cyclic sieving phenomena on generalized order ideals of posets; these correspond to Schröder paths in a special case. We also examine generalizations of alternating sign matrices arising from this construction and explore algebraic and geometric connections. This is a sequel to our paper, “Promotion and rowmotion.” (Received September 25, 2012)

1086-05-2757 **Paul Horn*** (phorn@math.harvard.edu) and **Gabor Lippner**. *3D floor planning and tree representations.*

A (2D) mosaic floorplan is a partitioning of a square into n rectangles. Schemes which can be used to represent and count these floorplans, under a suitable topological equivalence, have applications in chip design. A 3D mosaic floorplan is a partitioning of a box into n smaller boxes. Modern chip construction techniques, allowing chips with multiple layers, have fueled the desire to understand the number of 3D mosaic floorplans and how to represent them. For the 2D case, the number of unlabeled floorplans with n rectangles, up to topological equivalence, is exponential in n . For many classes of 3D floorplans the number of floorplans is also exponential. Notable among these are ‘slicing’ floorplans, where to obtain an n box floorplan one starts with an $n - 1$ box floorplans, and divides a box in two. In this talk, we discuss some of the difficulties with more general 3D floorplans, even with only two layers. In particular, if \mathcal{T}_n denotes the number of 3D floorplans with two levels, we show that $\log \mathcal{T}_n \sim \frac{1}{3}n \log n$, and hence F_n grows superexponentially in n . The upper bound comes from a representation scheme using trees, while the lower bound comes from a random construction. (Received September 25, 2012)

1086-05-2762 **Evan M. O’Dorney*** (odorney@college.harvard.edu). *Degree asymptotics of the numerical semigroup tree.*

A *numerical semigroup* is a subset Λ of the nonnegative integers that is closed under addition, contains 0, and omits finitely many nonnegative integers (called the *gaps* of Λ). The collection of all numerical semigroups may be visually represented by a tree of element removals, in which the children of a semigroup Λ are formed by removing one element of Λ that exceeds all existing gaps of Λ . In general, a semigroup may have many children or none at all, making it difficult to understand the number of semigroups at a given depth on the tree. We investigate the problem of estimating the number of semigroups at depth g with h children, showing that as g becomes large, it tends to a proportion φ^{-h-2} of all numerical semigroups, where φ is the golden ratio. (Received September 25, 2012)

1086-05-2775 **Steven Michael Senger*** (stevensenger@gmail.com), 120 Wilbur, A9, Newark, DE 19711. *Multiscale approach to the near-unit distance problem.*

The near-unit distance problem asks for bounds on the number of point pairs of an arbitrary large finite point set that are nearly a unit distance apart. We offer a novel approach to this problem which yields new upper bounds in a wide class of sets that are out of reach of previously employed techniques. (Received September 25, 2012)

1086-05-2790 **Brian Nakamura***, bnaka@math.rutgers.edu, and **Doron Zeilberger**. *Counting permutations with exactly r occurrences of a pattern.*

We will consider the problem of enumerating permutations that contain exactly r occurrences of a specified pattern. Previous work by Noonan and Zeilberger considered this problem for a few different patterns (such as the pattern 123) and gave a concrete method of enumeration for $r \leq 2$. We will discuss a modification to their approach that allows us to enumerate such permutations for more patterns as well as for larger r values. (Received September 25, 2012)

1086-05-2801 **Theodore Molla*** (tmolla@asu.edu), **H.A. Kierstead** and **Andrzej Czygrinow**.
Perfect tilings in graphs and digraphs.

A graph G has a perfect H -tiling if $|G| = k|H|$ and G contains k independent copies of H . We will discuss minimum degree conditions on both graphs and digraphs that ensure perfect tilings. An equivalent form of the Hajnal-Szemerédi Theorem states that if G is a graph on rk vertices and $\delta(G) \geq (r-1)k$ then G contains a perfect K_r -tiling. An example of our results is an extension of this to directed graphs. We show that for any r there exists n_0 such that if D is a directed graph on $n = rk \geq n_0$ vertices with $\min_{v \in V(D)} \{d^+(v) + d^-(v)\} \geq 2(r-1)k - 1$ then D contains k independent transitive tournaments on r vertices. Like most of the results we will present, this uses the probabilistic absorbing technique in a manner similar to Levitt, Sárközy and Szemerédi. (Received September 25, 2012)

1086-05-2802 **Alexander Burstein*** (aburstein@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059. *Equidistribution of some Euler-Mahonian statistics.*
Preliminary report.

We give a direct combinatorial proof of the equidistribution of two pairs of permutation statistics, (aid, des) and (inv, lec) , which have been previously shown to have the same joint distribution as (maj, exc) , the major index and the number of excedances of a permutation. Moreover, the triple $(\text{inv}, \text{lec}, \text{pix})$ was shown to have the same distribution as $(\text{maj}, \text{exc}, \text{fix})$, where fix is the number of fixed points of a permutation. We define a new statistic aix so that our bijection maps $(\text{inv}, \text{lec}, \text{pix})$ to $(\text{aid}, \text{des}, \text{aix})$. We also find an Eulerian partner dis for a Mahonian statistic mix defined using mesh patterns, so that (mix, dis) is equidistributed with (inv, des) . (Received September 25, 2012)

1086-05-2803 **Matthew Moynihan*** (mmoynihan@wooster.edu), Department of Mathematics, The College of Wooster, 1189 Beall Avenue, Wooster, OH 44691. *The Colored Eulerian Descent Algebra.*

Mantaci and Reutenauer first proved the existence of an algebra whose basis elements are formal sums of colored permutations with the same associated colored compositions (an extension of the descent set). Using Steingrímsson's definition of colored permutation descents, we describe a colored Eulerian descent algebra, which is a subalgebra of the Mantaci-Reutenauer algebra. We also describe a set of orthogonal idempotents which spans this colored Eulerian descent algebra. They include, as a special case, the familiar Eulerian idempotents found in the group algebra of the symmetric group. (Received September 25, 2012)

1086-05-2806 **Alexander Mikhail Komarinski*** (alexkomarinski@gmail.com), 24 E. Foothill Dr., Phoenix, AZ 85020, and **Meredith Harris**. *A New Proof of the Lecture Hall Theorem.*

Euler proved a bijection between integer partitions with distinct parts and integer partitions with odd parts. The lecture hall partitions can be thought of as a way to arrange the levels of seats in a lecture hall so every student may see the speaker. Bousquet-Melou and Eriksson provided a proof that there is a bijection between these lecture hall partitions and integer partitions of "small" odd parts, which generalizes Euler's celebrated result. In this presentation we provide a new Coxeter-free bijection using abacus diagrams and bounded partitions. (Received September 25, 2012)

1086-05-2812 **John Shareshian** (shareshi@math.wustl.edu) and **Michelle L Wachs*** (wachs@math.miami.edu). *A q -analog of generalized Eulerian numbers.*

An r -inversion of a permutation $\sigma \in S_n$ is an inversion $(\sigma(i) > \sigma(j))$ such that $0 < j - i \leq r$. The generalized Eulerian number $a_{n,k}^r$ is the number of permutations in S_n with exactly k r -inversions. When $r = 1$, the generalized Eulerian numbers are the usual Eulerian numbers. De Mari and Shayman proved, using the hard Lefschetz theorem of algebraic geometry, that the sequence $(a_{n,k}^r)_k$ is unimodal. We discuss a q -analog of $a_{n,k}^r$, which involves a well-known Mahonian permutation statistic of Rawlings, and we present several conjectures on them including one on unimodality. (Received September 25, 2012)

1086-05-2829 **Mikhail Mazin*** (mmazin@math.sunysb.edu), 17 Poplar Ave, Stony Brook, NY 11790. *Generalized q, t -Catalan Numbers and Jacobi Factors.*

We study combinatorics of cell decompositions of Jacobi factors of quasihomogeneous plane curve singularities. The cells are enumerated by certain Young diagrams, and the dimensions of cells can be computed in a combinatorial way. The resulting combinatorial theory turns out to be related to a generalization of (q, t) -Catalan numbers, geometry of the Hilbert scheme of points in the complex plane, representation theory of double affine Hecke algebras, and knot invariants of the link of the singularity. This is a joint work with Eugene Gorsky. (Received September 25, 2012)

1086-05-2841 **Senmei Yao*** (syao93@marianuniversity.edu), 45 South National Avenue, Fond du Lac, WI 54935. *Group Connectivity of Ryjáček's closure of claw-free graphs.*

Tutte introduced the theory of nowhere zero flows and showed that a plane graph G has a face k -coloring if and only if G has a nowhere zero A -flow, for any Abelian group A with $|A| \geq k$. In 1992 Jaeger et al extended nowhere zero flows to group connectivity of graphs: given an orientation D of a graph G , if for any $b: V(G) \mapsto A$ with $\sum_{v \in V(G)} b(v) = 0$, there always exists a map $f: E(G) \mapsto A - \{0\}$, such that at each $v \in V(G)$,

$$\sum_{e=vw \text{ is directed from } v \text{ to } w} f(e) - \sum_{e=uv \text{ is directed from } u \text{ to } v} f(e) = b(v)$$

in A , then G is A -connected. Let Z_3 denote the cyclic group of order 3. Jaeger et al conjectured that every 5-edge-connected graph is Z_3 -connected. We proved that for a claw-free graph G with $\delta(G) \geq 7$, if $cl(G) \in \langle Z_3 \rangle$, then $G \in \langle Z_3 \rangle$. (Received September 25, 2012)

1086-05-2856 **Julianna Tymoczko*** (jtymoczko@smith.edu), Clark Science Center, Smith College, Northampton, MA 01063. *Generalized splines and GKM theory.*

Given a graph, we describe a way to build a ring which we call the ring of generalized splines, because it generalizes the usual construction of algebraic splines. These rings also generalize equivariant cohomology rings as constructed by GKM theory, a well-known construction in algebraic topology that uses tools from algebraic combinatorics. We discuss results in the theory of generalized splines together with open questions, including questions about the representations associated to the generalized splines of a graph. Time permitting, we will elaborate on the geometric motivation and context for this work, including important geometric representations of the symmetric group. (Received September 25, 2012)

1086-05-2947 **Amanda Redlich*** (aredlich@math.rutgers.edu). *Graph decomposition and parity.*

Motivated by a recent extension of the zero-one law, we study the distribution of disconnected subgraphs in the random graph modulo q . To do this, we define a “gluing” and “decomposition” rule for graphs, then determine which graphs are glueable and decomposable (there is a natural analogy here with the reconstruction conjecture). We fully characterize the distributions of two-component graphs in the random graph. We also give a sufficient condition for graphs with arbitrarily many components to be uniformly distributed. (Received September 26, 2012)

1086-05-2975 **T. R. Whitt*** (trw0003@auburn.edu), Auburn University, Roosevelt Dr, Department of Mathematics Parker 221, Auburn University, AL 36849, and **C. A. Rodger** (rodgerc1@auburn.edu). *Path Decompositions of the Kneser Graph.*

The Kneser Graph, $KG_{n,k}$, is the graph whose vertices correspond to the k -element subsets of n elements, and where two vertices are connected if and only if their corresponding sets are disjoint. A P_n -decomposition of a graph, G , is a partition of the edges of G into sets, each element of which induces an edge-disjoint copy of P_n , where P_n is a simple path of length n . Necessary and sufficient conditions for P_3 and P_4 decompositions of $KG_{n,2}$ are discussed, along with generalizations of the results. (Received September 26, 2012)

1086-05-2977 **Nicholas Teff*** (nicholas-teff@uiowa.edu), University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242. *Divided difference operator on highest root Hessenberg varieties.* Preliminary report.

In this talk we construct a family of flow-up classes in the equivariant cohomology of highest root Hessenberg varieties, a smooth subvariety of the full flag variety. This construction is via a generalized divided difference operator using the GKM presentation of equivariant cohomology. This work generalizes earlier work for full flag variety where the analogous flow-up classes are Schubert classes. As in the classical case the definition of the divided difference operator depends heavily the Weyl group action, the Bruhat order and the root system. (Received September 26, 2012)

1086-05-2998 **Jon Schneider***, MIT, Cambridge, MA. *Polynomial sequences of binomial-type occurring in graph theory.*

In this paper, we show that the solution to a large class of “tiling” problems is given by a polynomial sequence of binomial type. More specifically, we show that the number of ways to place a fixed set of polyominoes on an n by n toroidal chessboard such that no two polyominoes overlap is eventually a polynomial in n , and that certain sets of these polynomials satisfy binomial-type recurrences. We exhibit generalizations of this theorem to higher dimensions and other lattices. Finally, we apply the techniques developed in this paper to resolve an open question about the structure of coefficients of chromatic polynomials of certain grid graphs (namely that they also satisfy a binomial-type recurrence). (Received October 02, 2012)

06 ► Order, lattices, ordered algebraic structures

1086-06-642 **R E Jamison, A J Gilbert*** (adamgilbert@math.uri.edu) and **A M Heissan**.
Separation in Gap Closures.

Gap closures are natural extensions of poker closure. In gap closure, the ground set is the integers. An ordered pair (g, h) of non-negative integers will be called a *gap type*. For $S \subset \mathbb{Z}$, a point $p \in \mathbb{Z}$ is a (g, h) -gap point of S provided the g integers to the left of p are in S and the h integers to the right of p also belong to S . We say that S is (g, h) -closed if S contains all of its (g, h) -gap points. Similarly, if \mathcal{G} is a set of gap types, we say that S is \mathcal{G} -closed if S contains all of its (g, h) -gap points for each $(g, h) \in \mathcal{G}$.

We show that no gap closures satisfy S_4 . We also show that there are gap closures which satisfy S_3 , and provide separating examples for each of S_0, S_1, S_2 and S_3 . Furthermore, we prove some general results on gap closures and the separation axioms. (Received September 10, 2012)

1086-06-1150 **David E. Brown and Larry J. Langley***, University of the Pacific, Mathematics Department, 3601 Pacific Ave, Stockton, CA 95211. *Construction of k -interval orders*. Preliminary report.

Interval k -orders, $(V, <)$ are a modification of interval orders with the vertices partitioned into k classes having an interval representation with the following properties. Intervals of vertices of different classes are ordered in the usual way, with $x < y$ if and only if the interval of x is entirely to the left of the interval for y . Within a class, the intervals are proper, that is no interval is entirely contained in another, and $x < y$ if and only if the left hand point of the interval for x is to the left of the left hand point of the interval for y .

Interval orders may be constructed from their predecessor and successor sets. In this talk we look at a similar construction for interval k -orders, under certain partitions. (Received September 19, 2012)

1086-06-1928 **Martha Lee Hollist Kilpack*** (martha.kilpack@oneonta.edu). *Closure operators and algebraic closure operators*.

Given a complete lattice, the set of closure operators on that lattice forms a complete lattice. It will be shown that the set of algebraic closure operators of a lattice forms a complete lattice which is a sub-lattice of the closure operators. (Received September 24, 2012)

1086-06-2185 **Vijay Madhukar Patankar and Arun Kumar Kuchibhotla*** (karun3kumar@gmail.com). *Gauss Composition and Bhargava Cubes*. Preliminary report.

In his work in 1801, Gauss laid foundations to composition of binary quadratic forms by using bilinear equations. This was later reformulated in 2001 by Manjul Bhargava in his Princeton thesis by using planes of symmetries of cubes. In this paper, we describe Gauss composition and give an algorithm to find a cube on which two given quadratic forms live. (Received September 25, 2012)

1086-06-2759 **Tanya Nichole Riston*** (tnr5033@psu.edu), 5830 Georgetown Drive, Erie, PA 16509. *Extensions of Finite Distributive Lattices using $\text{Min}(L)$* . Preliminary report.

A lattice is a partially ordered set where every pair of elements has a least upper bound and a greatest lower bound. Examples of distributive lattices include, but are not limited to, collection of open sets of a topological space and collection of ideals of a commutative ring. For a given distributive lattice L , the concepts of prime elements, $\text{Spec}(L)$, and minimal prime elements, $\text{Min}(L)$, of L are of great importance and can be used to understand various lattice-theoretic properties.

We will discuss the space of $\text{Min}(L)$ for a given finite distributive lattice L . Furthermore, using $\text{Min}(L)$ we will define various extensions of lattices, namely, rigid extension, r -extension, and r^b -extension, and results related to them. The ultimate goal is to answer an open question related to the extensions of finite distributive lattices: Is a rigid extension between finite distributive lattices equivalent to the r -extension? (Received September 25, 2012)

08 ► General algebraic systems

1086-08-621 **David M. Clark*** (clarkd@newpaltz.edu), Mathematics Department, Faculty Office Building E1, SUNY, New Paltz, NY 12561. *Generating algebraic terms by evolutionary computation*.

Assume we are given a primal algebra and a table for an operation on its underlying set. A simple computation shows that the problem of finding a term (a switching circuit) to represent (compute) that operation by any

kind of exhaustive search is computationally unfeasible in all but the simplest cases. In 2008 the speaker was part of a team that won first place in the ACM's GECCO Humie competition by giving experimental evidence that evolutionary computation can sometimes be effectively used to find these terms. Success in this process requires that small mutations in a term result in small changes to the resulting term operation. In other words, the map of term to term operation must be continuous. In this talk we present a theorem which gives testable conditions on a finite groupoid for this to be true, and we give evidence that these conditions hold for almost all finite groupoids. (Received September 09, 2012)

1086-08-1485 **George J. Schaeffer*** (gschaeff@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *LMS-complete subsets of \mathbb{Z} .*

A subset S of \mathbb{Z} is said to be length multiset complete (LMS-complete) if for every finite multiset U there is an element x of the restricted block monoid $\mathcal{B}(\mathbb{Z}; S)$ satisfying $\mathcal{L}(x) = U$. The study of such sets began with the following theorem due to Kainrath: $S = \mathbb{Z}$ is itself a LMS-complete subset of \mathbb{Z} . This means that the factorization theory in Krull domains with infinite cyclic class group is (in some respects) “as flexible as possible.”

In this expository talk I will exhibit some more recently discovered examples of LMS-complete subsets. For example, I will sketch the proof that S is LMS-complete when either (1) S is closed under negation and has nonzero natural density, or (2) S is an arithmetic progression. (Received September 22, 2012)

1086-08-1766 **G. Alan Cannon** (1kabza@selu.edu), 500 Western Ave., Hammond, LA 70402, **Lucyna Kabza*** (1kabza@selu.edu), Department of Mathematics, Southeastern Louisiana University, Hammond, LA 70402, **C. J. Maxson** (1kabza@selu.edu), 500 Western Ave., Hammond, LA 70402, and **Kent M. Neuerburg** (1kabza@selu.edu), 500 Western Ave., Hammond, LA 70402. *Rings and Covered Groups II.*

For a finite group G with a cover by abelian subgroups, consider the ring of functions that act as endomorphisms on each subgroup in the cover. Properties of this ring are explored. In particular, conditions for and consequences of simplicity are investigated. (Received September 24, 2012)

1086-08-2522 **Rob Laber***, UCSC, Mathematics Department, 1156 High St., Santa Cruz, CA 95064, and **Geoffrey Mason**. *Pseudo Vertex Operator Algebras and Conformal Flows*. Preliminary report.

A vertex operator algebra (VOA) is a vertex algebra V endowed with, among other things, an endomorphism $L(0)$ which acts semisimply on V with integral spectrum. A psuedo vertex operator algebra generalizes the notion of VOA by relaxing these requirements on $L(0)$. We show that, given a VOA V , one can generate a family of psuedo VOAs by “shifting” the $L(0)$ operator, and we show that there is a finite dimensional Lie algebra associated to V which serves as a coarse moduli space for this family. This moduli space is related to the notion of “conformal flow” in physics. (Received September 25, 2012)

11 ► Number theory

1086-11-3 **Jordan S. Ellenberg*** (ellenber@math.wisc.edu). *How to Count with Topology.*

What is the probability that a random integer is squarefree? Prime? How many number fields of degree d are there with discriminant at most X ? What does the class group of a random quadratic field look like? These questions, and many more like them, are part of the very active subject of *arithmetic statistics*. Many aspects of the subject are well-understood, but many more remain the subject of conjectures, by Cohen-Lenstra, Malle, Bhargava, Batyrev-Manin, and others.

In this talk, I explain what arithmetic statistics looks like when we start from the field $\mathbf{F}_q(x)$ of rational functions over a finite field instead of the field \mathbf{Q} of rational numbers. The analogy between function fields and number fields has been a rich source of insights throughout the modern history of number theory. In this setting, the analogy reveals a surprising relationship between conjectures in number theory and conjectures in topology about stable cohomology of moduli spaces, especially spaces related to Artin's braid group. I will discuss some recent work in this area, in which new theorems about the topology of moduli spaces lead to proofs of arithmetic conjectures over function fields, and to new, topologically motivated questions about counting arithmetic objects. (Received September 24, 2012)

- 1086-11-22 **Maxwell Anselm** and **Steven H Weintraub*** (shw2@lehigh.edu), Dept. of Mathematics, Lehigh University, Bethlehem, PA 18015. *A Generalization of Continued Fractions.*

Let N be an arbitrary positive integer. We consider continued fractions of the form

$$a_0 + \frac{N}{a_1 + \frac{N}{a_2 + \frac{N}{a_3 + \cdots}}},$$

with a_0 a nonnegative integer and a_1, a_2, a_3, \dots positive integers, and refer to them as cf_N expansions.

The $N > 1$ case has both a number of similarities to and some surprising differences from the classical, i.e., $N = 1$, case.

For $N > 1$, every positive real number x_0 has infinitely many cf_N expansions. We develop a natural notion of the best cf_N expansion of x_0 .

We show, for example, that for $N > 1$, every quadratic irrationality has both periodic and nonperiodic cf_N expansions, and that in many cases the best cf_N expansion of a quadratic irrationality is periodic, but, on the grounds of extensive computational results, we conjecture that this is *not* always the case. We establish further results about the form of the best cf_N expansion when it is periodic; this form sometimes but not always more or less resembles the form in the classical case.

In the classical case, continued fractions have a close relationship with Pell's equation, and we investigate the analog for $N > 1$ as well. (Received May 10, 2012)

- 1086-11-41 **Eduardo Giovanni Aponte*** (edugio56@yahoo.com), San Antonio, Miranda 1204, Venezuela. *Partial sums and geometric series.*

Starting with the geometrical series, a partial sums method is developed for n terms where each term is raised to the power of m , first considering $m \in \mathbb{N}$, and then $m \in \mathbb{R}$.

The explanation of the method begins with the generalization of a class of Bernoulli's partial sums, extending it then to any $m \in \mathbb{N}$.

Defining generating functions, the method is extended to the sums of natural numbers alternating in sign, sums of odd natural numbers and sums of odd natural numbers alternating in sign. Furthermore, such generating functions admit an additional generalization, which allows finding a set of partial sums of the geometrical series. These partial sums, depends on two parameters which are $m \in \mathbb{R}$ and $b \in \mathbb{R}^+$, where \mathbb{R}^+ are all positive reals excluding 0.

An application for $m < 0$ is the computation of an integral expression of partial sums of the Reimann ζ function, where $b = 1$ and $m < -1$. This methodology is used to calculate the integral expression for partial sums of natural numbers, where each term of the sum is raised to any $m \geq 0$ power. (Received September 23, 2012)

- 1086-11-70 **Carl B. Pomerance** (carlp@math.dartmouth.edu), 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755, and **Hee-Sung Yang*** (hee-sung.yang.12@dartmouth.edu), 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755. *Variant of a theorem of Erdős on the sum-of-proper-divisors function.*

In 1973, Erdős proved that the upper density of the set $s(\mathbb{N})$ is less than 1, where $s(n) := \sigma(n) - n$ is the sum of the proper divisors of n . We investigate the analogous question where σ is replaced with similar divisor functions, such as the sum-of-unitary-divisors function σ^* (which sums those divisors d of n co-prime to n/d). We use a modified version of Erdős's original argument from the aforementioned work to prove that the upper density of $s^*(\mathbb{N})$ is less than 1, thereby showing that there are infinitely many integers not in the image of s^* . In one of the cases, the theory of covering congruences makes a surprising appearance. We also present an algorithm that allows us to enumerate the total number of integers not in $s^*(\mathbb{N})$ up to 10^8 (the previous known result, by David Wilson in 2001, was up to 10^5) and conjecture the density of the set $s^*(\mathbb{N})$ based on this result. (Received July 19, 2012)

- 1086-11-77 **Graeme Taylor*** (magdt@bristol.ac.uk) and **Gary Greaves**. *Lehmer's conjecture for Hermitian matrices over the Eisenstein and Gaussian integers.*

We solve Lehmer's problem for a class of polynomials arising from Hermitian matrices over the Eisenstein and Gaussian integers: any such polynomial has Mahler measure at least $\lambda_0 = 1.17628\dots$. To do so, we classify (via graphs) all such matrices with Mahler measure at most 1.3. (Received July 07, 2012)

1086-11-79 **John Jones***, jj@asu.edu, and **David Roberts**. *The Tame-Wild Principle*. Preliminary report.

When computing complete lists of number fields using class field theory, one often has to relate the discriminants of various subfields of a Galois extension with a given Galois group. These may take the form of a product of powers of discriminants of one collection of subfields divides a similar product for another set of subfields.

One can easily determine divisibility conditions for these discriminants under the assumption that all ramification is tame; it is essentially a group theoretic computation. We consider the extent to which relations determined by tame ramification are guaranteed to hold for wildly ramified extensions as well, and prove that they do in some situations. For example, if K is a number field and L is the Galois closure for K/\mathbf{Q} , we prove $|D_K| \geq |D_L|^{\alpha(G)}$ where $\alpha(G)$ is a constant computed from $G = \text{Gal}(L/\mathbf{Q})$ based on tame ramification. (Received July 09, 2012)

1086-11-84 **Jacqueline Anderson*** (jackie@math.brown.edu), Providence, RI 02912. *Bounds on the radius of the p -adic Mandelbrot set.*

Let $f(z) = z^d + a_{d-1}z^{d-1} + \cdots + a_1z \in \mathbb{C}_p[z]$ be a degree d polynomial. We say f is *post-critically bounded*, or PCB, if all of its critical points have bounded orbit under iteration of f . It is known that if $p \geq d$ and f is PCB, then all critical points of f have p -adic absolute value less than or equal to 1. We give a similar result for $\frac{1}{2}d \leq p < d$. (Received July 10, 2012)

1086-11-92 **David Krumm*** (dkrumm@uga.edu). *Computing algebraic numbers of bounded height.*

Given a number field K and a bound B , we describe an algorithm for listing all the elements of K having relative height at most B . This method shows dramatic improvements in performance over previously existing methods. We will discuss an application of this algorithm to the computation of sets of preperiodic points for quadratic polynomials over number fields. (Received September 04, 2012)

1086-11-111 **Benjamin Linowitz*** (linowitz@umich.edu), Department of Mathematics, University of Michigan, 530 Church Street, Ann Arbor, MI 48109. *Lattice-theoretic methods in spectral geometry.*

Inverse spectral geometry asks the extent to which the topology and geometry of a Riemannian manifold M is determined by its spectrum with respect to the Laplace-Beltrami operator. Whereas volume and scalar curvature are spectral invariants, the isometry class is not. In this talk we will review several constructions of isospectral but not isometric Riemannian manifolds which are lattice-theoretic in nature. We will then construct, using the arithmetic of orders in quaternion algebras, examples of isospectral but not isometric hyperbolic surfaces which have extremely small volume. These examples have minimal volume amongst all isospectral surfaces arising from maximal arithmetic Fuchsian groups. This is joint work with Peter Doyle and John Voight. (Received July 20, 2012)

1086-11-124 **Anna Haensch*** (ahaensch@wesleyan.edu), Department of Mathematics and C.S., 265 Church St., Middletown, CT 06459. *Almost universal ternary sums of squares and $(2p+2)$ -gonal numbers.*

A fundamental question in the study of integral quadratic forms is the representation problem which asks for an effective determination of the set of integers represented by a given quadratic form. A related and equally interesting problem is the representation of integers by inhomogeneous quadratic polynomials. Weighted sums of generalized m -gonal numbers, defined by $P_m(x) = \frac{(m-2)x^2 - (m-4)x}{2}$ for $x \in \mathbb{Z}$, give rise to an interesting family of inhomogeneous quadratic polynomials. Consider the polynomial

$$H(x, y, z) = \alpha P_\ell(x) + \beta P_m(y) + \gamma P_n(z)$$

with $\alpha, \beta, \gamma \in \mathbb{Z}^+$ and $\ell, m, n \in \{4, 2p+2\}$ for p prime. We say that H is *almost universal* if it represents all but finitely many positive integers. Relying on the theory of quadratic lattices and primitive spinor exceptions, we give a list of necessary and sufficient conditions on α, β and γ , under which H is almost universal. These results can be extended to more general statements about almost universal inhomogeneous quadratic polynomials, under some mild arithmetic conditions.

(Received July 26, 2012)

1086-11-153 **Sheng-Chi Liu*** (scliu@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368, and **Riad Masri** and **Matt Young**. *Subconvexity and equidistribution of Heegner points in the level aspect.*

Let q be a prime and $-D < -4$ be an odd fundamental discriminant such that q splits in $\mathbb{Q}(\sqrt{-D})$. For f a weight zero Hecke-Maass newform of level q and Θ_χ the weight one theta series of level D corresponding to

an ideal class group character χ of $\mathbb{Q}(\sqrt{-D})$, we establish a hybrid subconvexity bound for $L(f \times \Theta_\chi, s)$ at $s = 1/2$ when $q \asymp D^\eta$ for $0 < \eta < 1$. With this circle of ideas, we show that the Heegner points of level q and discriminant D become equidistributed, in a natural sense, as $q, D \rightarrow \infty$ for $q \leq D^{1/20-\varepsilon}$. Our approach to these problems is connected to estimating the L^2 -restriction norm of a Maass form of large level q when restricted to the collection of Heegner points. We furthermore establish bounds for quadratic twists of Hecke-Maass L -functions with simultaneously large level and large quadratic twist, and hybrid bounds for quadratic Dirichlet L -functions in certain ranges. This is joint work with Riad Masri and Matt Young. (Received July 30, 2012)

1086-11-154 **Alon Levy, Michelle Manes and Bianca Thompson*** (bat7@hawaii.edu), 2565 McCarthy Mall, Honolulu, HI 96822. *Explicit Uniform Bounds for Preperiodic Points in Families of Twists.*

Let ϕ be a morphism of \mathbb{P}^N defined over a number field K . We prove that there is a bound B depending only on ϕ such that every twist of ϕ has no more than B K -rational preperiodic points. (This result is analogous to a result of Silverman for abelian varieties.) For two specific families of quadratic rational maps over \mathbb{Q} , we find the bound B explicitly. (Received July 30, 2012)

1086-11-168 **Nicolas Allen Smoot*** (mathdept@armstrong.edu), Armstrong Atlantic State University, 11935 Abercorn Street, Savannah, GA 31419. *The Structure of Consecutive Octic Residues.* Preliminary report.

One fascinating property of power residues modulo p , for some odd prime p , is that there are many beautiful patterns in their distribution among $\mathbb{Z}/p\mathbb{Z}$. The purpose of this talk is to discuss one of those patterns—specifically, the occurrence of consecutive pairs of power residues. The recent article titled “Enumeration of Triangles in Quartic Residue Graphs,” addressed the number of pairs of consecutive quartic residues modulo p , for an odd prime p , where the only nontrivial case is that in which $p \equiv 1 \pmod{4}$. We wish to extend the authors’ methods to derive a formula for the number of pairs of consecutive octic residues for a given prime p , where the only nontrivial case is that in which $p \equiv 1 \pmod{8}$. Since the formula for the number of pairs of consecutive quadratic residues is trivial to derive, and the more difficult quartic and octic equivalents are now known, we can then examine similarities in the structure of these formulas, and discuss the possibility of generalizing them to describe the number of consecutive 2^t residues modulo p . (Received August 01, 2012)

1086-11-171 **Hayan Nam*** (hayannam@yonsei.ac.kr), Department of Mathematics, Yonsei University, Seoul, 120-749, South Korea, **SeungKyung Park** (sparky@yonsei.ac.kr), Department of Mathematics, Yonsei University, Seoul, 120-749, South Korea, and **Jaebum Sohn** (jsohn@yonsei.ac.kr), Department of Mathematics, Yonsei University, Seoul, 120-749, South Korea. *A generalization of the pentagonal number theorem.*

In this talk, we first define a model that is called Fix-Project model and using it to prove the Euler’s pentagonal number theorem. Also we provide some new identities that generalize the Euler’s pentagonal number theorem. (Received August 02, 2012)

1086-11-205 **Chad Awtrey*** (cawtre@elon.edu), Elon University, NC. *Computing Galois groups of ramified 3-adic fields of degree 12.*

Let K be a number field and p a prime. For investigating some questions about K , it is often useful to have refined information concerning its associated p -adic algebra,

$$K \otimes \mathbf{Q}_p \simeq \prod K_{p,i}.$$

Here each $K_{p,i}$ is a finite extension of the p -adic numbers \mathbf{Q}_p . Consequently, Jones and Roberts have constructed a database of local fields which aims to catalogue important invariants for each of the finitely many extensions of \mathbf{Q}_p for various low degrees. The most complicated cases arise when p divides the degree of the extension. In this talk, we focus on degree 12 extensions of \mathbf{Q}_3 and discuss our approach for computing the number of such extensions as well as their local Galois groups. (Received August 07, 2012)

1086-11-207 **Luis A. Lomeli*** (lomeli@math.purdue.edu), Department of Mathematics, The University of Oklahoma, Norman, OK 73019-3103. *L-functions and functoriality for the quasi-split classical groups over function fields.* Preliminary report.

We study L -functions for products of globally generic representations of classical groups and general linear groups via the Langlands-Shahidi method over function fields. The Converse Theorem of Cogdell and Piatetski-Shapiro leads us towards a Langlands functorial lift from globally generic cuspidal automorphic representations of classical groups to automorphic representations of $\mathrm{GL}(N)$. A study of the image of functoriality allows us to express the lift to $\mathrm{GL}(N)$ as an isobaric sum. Combining our results with the work of Lafforgue on the Langlands

correspondence for $GL(N)$ over function fields, we establish the Ramanujan Conjecture for the classical groups. (Received August 07, 2012)

1086-11-211 **Alexander Carl Mueller*** (amuell@umich.edu), 111 North Seventh Street, Apartment 2, Ann Arbor, MI 48103. *Artin-Schreier Curves: From Improved Bounds For Rational Points To Relations Among Frobenius Angles.*

An Artin-Schreier curve X (associated with an equation of the form $y^p - y = f(x)$) must satisfy the familiar Weil bound

$$||X(\mathbb{F}_{p^n})| - (p^n + 1)| < (\deg f - 1)(p - 1)p^{\frac{n}{2}}$$

but in many cases stronger bounds hold. In particular, these curves satisfy bounds of the form

$$||X(\mathbb{F}_{p^n})| - (p^n + 1)| < C_{d,n} p^{\frac{n+1}{2}}$$

where $C_{d,n}$ is a constant that depends on $d := \deg f$ and n but not p . I will describe a new approach to proving results of the latter type. Specifically, I will define a class of auxiliary varieties with an action of the symmetric group and explain how a related L-function can be analyzed to produce these bounds. In addition, I will indicate how much more information can be extracted from this L-function; for example, if d is “small” then the ratio of any two roots of the zeta function of X must be a root of unity. (Received August 07, 2012)

1086-11-214 **Alexander Carl Mueller*** (amuell@umich.edu), 111 North Seventh Street, Apartment 2, Ann Arbor, MI 48103. *Counting Rational Points Modulo p On Artin-Schreier Curves.*

For a variety Z defined over a finite field k of characteristic p , it is often much easier to compute $|Z(k)|$ modulo p than otherwise. For example, the Chevalley-Waring theorem states that if F is a polynomial of degree d in n variables and $n > d$, then the number of solutions to the equation $F = 0$ is congruent to 0 modulo p . I will state an arithmetic version of this theorem that applies to any Artin-Schreier curve X (associated with an equation of the form $y^p - y = f(x)$) and use it to demonstrate a congruence

$$|X(\mathbb{F}_{p^n})| \equiv J \text{ modulo } p^v$$

for a certain generalized Jacobi sum J and positive integer v . (Received August 07, 2012)

1086-11-243 **Caroline L. Turnage-Butterbaugh*** (clbutter@go.olemiss.edu), University, MS 38677. *Large gaps between zeros of Dedekind zeta-functions of quadratic number fields.* Preliminary report.

Let K be a quadratic number field with discriminant d . The Dedekind zeta-function attached to K can be expressed by $\zeta_K(s) = \zeta(s)L(s, \chi_d)$ for $s \neq 1$, where $\zeta(s)$ is the Riemann zeta-function, the character χ_d is the Kronecker symbol associated to d , and $L(s, \chi_d)$ is the corresponding Dirichlet L-function. Using the mixed second moments of $\zeta_K(\frac{1}{2} + it)$ and its derivatives, we prove the existence of gaps between consecutive zeros of $\zeta_K(s)$ on the critical line which are much larger than the average spacing. We also conjecture a more precise main term for these moments using a modification of the recipe of Conrey, Farmer, Keating, Rubenstein, and Snaith combined with ideas of Hughes and Young. (Received August 12, 2012)

1086-11-248 **D. R. Heath-Brown** and **Lillian B. Pierce*** (lillian.pierce@maths.ox.ac.uk). *Simultaneous Prime Values of Pairs of Quadratic Forms.*

We prove that under a certain geometric assumption, any two quadratic forms with integer coefficients simultaneously attain values infinitely often in any specified subset of the integers, as long as the elements of the set satisfy certain local conditions, and the set is not too sparse. The sparsity threshold is dependent upon the number of variables in the quadratic forms, as well as on the forms themselves. In particular, we show that 5 variables suffice in the case where the target set is the prime numbers, so that any two quadratic forms in 5 variables or more, which satisfy the relevant geometric condition, simultaneously attain prime values infinitely often. The proof proceeds via an application of the circle method, and in particular pioneers a two-dimensional version of a Kloosterman refinement. (Received August 13, 2012)

1086-11-252 **Cassie L Williams*** (willi5c1@jmu.edu). *Enumerating abelian varieties using matrix groups.* Preliminary report.

The Frobenius endomorphism of an abelian variety A/\mathbb{F}_q acts as a symplectic similitude on the torsion subgroups $A[\ell^n](\overline{\mathbb{F}}_q)$. In 2003, Gekeler used an equidistribution assumption on the elements of $GL_2(\mathbb{Z}/\ell^r)$ to show that the number of elliptic curves with certain characteristics is related, via results of Sato-Tate and the class number, to the Euler factors of the L -function of a quadratic imaginary field. By determining the sizes of conjugacy classes of Frobenius elements in the groups $GS_{2g}(\mathbb{Z}/\ell^r)$ and applying a theorem of Everett Howe, we will extend Gekeler’s heuristic to higher dimensional abelian varieties. (Received August 13, 2012)

1086-11-259 **Rachel M. Davis*** (rdavis@math.wisc.edu), Madison, WI 53706. *Generalizing Traces of Frobenius for Metabelian Galois Representations*. Preliminary report.

Given an elliptic curve E over \mathbb{Q} , there is an associated Galois representation to $\mathrm{GL}_2(\mathbb{Z}')$, obtained at the finite level by considering the action of Galois on the ' n -torsion points of E . We are especially interested in the images of the Frobenius elements under this map. Since the images of these elements are only well-defined up to conjugacy, we are interested in conjugacy invariants such as the trace and determinant. There is a more general representation (related to the fundamental group of the elliptic curve minus a point) to the automorphism group of a free pro-' ℓ ' group on 2 generators. Note that $\mathrm{GL}_2(\mathbb{Z}')$ is the automorphism group of an abelian group. I consider a representation to an automorphism group of a metabelian group that reduces to the ' ℓ -adic representation described above. I consider possible conjugacy invariants for this larger representation. (Received August 14, 2012)

1086-11-262 **Robert M Sulman*** (sulmanrm@oneonta.edu), S.U.N.Y. Oneonta, Mathematics Computer Science, and Statistics, Department, Oneonta, NY 13820. *Title: Orbits under polynomials that coincide with subgroups of the units of $\mathbb{Z}/n\mathbb{Z}$* . Preliminary report.

Let $G=(\mathbb{Z}/n\mathbb{Z})^*$ be the group of units of the ring $(\mathbb{Z}/n\mathbb{Z}, +, \bullet)$, and suppose that f is a polynomial with integer coefficients. We explore the orbits under f , and ask if any algebraic structure is contained in such orbits. In particular: When is the orbit of 1 under f a cycle? If it is a cycle, do its elements form a subgroup of G ? In this case, what algebraic structure is seen in this orbit and other orbits? When f is a product of more than one cycle, the orbit of 1 may coincide with a (proper) subgroup H of G . When this occurs, there is a natural, yet varied correspondence between the cosets of H and the cycles of f . And finally, when we form a conjugate of such an f by another bijection g from G to G , the algebraic structure of the orbit of 1 under f is sometimes altered. (Received August 14, 2012)

1086-11-266 **Holley A Friedlander*** (holleyf@math.umass.edu), Department of Mathematics and Statistics, Lederle Graduate Research Tower, Amherst, MA 01003. *Twisted Weyl group multiple Dirichlet series over the rational function field*. Preliminary report.

Let K be a global field and Φ a reduced root system of rank r . Let $n \geq 1$ be an integer so that K contains all $2n^{th}$ roots of unity. A degree n Weyl group multiple Dirichlet series of type Φ for K is a Dirichlet series in r complex variables with meromorphic continuation to \mathbb{C}^r satisfying a group of functional equations isomorphic to the Weyl group of Φ . Such series conjecturally arise as Whittaker coefficients of Eisenstein series on metaplectic groups and are a tool for performing certain estimates in analytic number theory.

This poster considers the case when K is an algebraic function field defined over a finite field. We first define twisted Weyl group multiple Dirichlet series, which are rational functions in several variables in this case. We then describe a new analogy between these rational functions and characters of representations of the Lie algebra associated to Φ . In particular, we show that when K is the rational function field these rational functions may be written uniquely as a weighted sum over "irreducible" elements. This result is part of a broader goal to understand how these rational functions encode the combinatorics of Φ and the geometry of K . (Received August 14, 2012)

1086-11-270 **Hester K. S. Graves*** (gravesesh@mast.queensu.ca) and **M. Ram Murty**. *The abc Conjecture and non-Wieferich primes in Arithmetic Progressions*.

Silverman proved that, if one assumes the abc conjecture, then there are $\gg \log x$ non-Wieferich primes for base a for all $a \geq 2$. We show that for any $a \geq 2$ and any fixed $k \geq 2$, there are $\gg \log x / \log \log x$ primes $p \leq x$ such that $a^{p-1} \not\equiv 1 \pmod{p^2}$ and $p \equiv 1 \pmod{k}$, under the assumption of the abc conjecture. MSC 11A41, 11B25. (Received August 14, 2012)

1086-11-274 **Dawn Nelson*** (dnelson@bates.edu), Bates College, Department of Mathematics, 3 Andrews Rd, Lewiston, ME 04240. *A Variation on Leopoldt's Conjecture for Galois Number Fields*.

Leopoldt's Conjecture is a statement about the relationship between the global and local units of a number field. Informally the conjecture states that the \mathbb{Z}_p -rank of the diagonal embedding of the global units into the product of *all* local units equals the \mathbb{Z} -rank of the global units. We consider the question: Can we say anything about the \mathbb{Z}_p -rank of the diagonal embedding of the global units into the product of *some* local units? We answer the question in the affirmative. (Received August 15, 2012)

1086-11-275 **Leslie Horton*** (lhorton@wmcarey.edu), William Carey University, Box 164, 498 Tuscan Avenue, Hattiesburg, MS 39401. *Sunburst Graphs and Independent Sets.*

The enumeration of independent vertex sets in graphs was inaugurated by Proding and Tichy who defined the Fibonacci number $f(G)$ of a graph G to be the total number of independent vertex sets in G . This counting was refined by Hopkins and Staton who defined, for nonnegative k , the parameter $f_k(G)$ to be the number of k -element vertex sets in G . They proposed using the obvious identity

$$\sum_{k \geq 0} f_k(G) = f(G)$$

to generate combinatorial identities. The purpose of this talk will be the determination of these parameters for a class of graphs, the "Sunburst Graphs," defined here for the first time. The resulting identity involves the well-known Pell-Lucas numbers. (Received August 15, 2012)

1086-11-284 **Shabnam Akhtari, Chantal David, Heekyoung Hahn and Lola Thompson*** (lola@math.uga.edu). *How often is $\#E(\mathbb{F}_p)$ squarefree?*

Let E be an elliptic curve over \mathbb{Q} . For each prime p of good reduction, E reduces to a curve E_p over the finite field \mathbb{F}_p with $\#E_p(\mathbb{F}_p) = p+1-a_p$, where $|a_p(E)| \leq 2\sqrt{p}$. In this talk, we discuss the problem of determining how often $\#E(\mathbb{F}_p)$ is squarefree. Our results in this vein are twofold. For any fixed curve E , we give an asymptotic formula for the number of primes up to X for which $\#E_p(\mathbb{F}_p)$ is squarefree. This resolves affirmatively a conjecture of David and Urroz. Moreover, we use sieve methods to improve upon a result of Gekeler that computes the average number of primes up to X for which $\#E_p(\mathbb{F}_p)$ is squarefree (over curves E in a suitable box). This talk is based on joint work with Shabnam Akhtari, Chantal David, and Heekyoung Hahn. (Received August 15, 2012)

1086-11-296 **Andrew Bremner*** (bremner@asu.edu). *Arithmetic progressions of squares in cubic fields.* Euler showed that the length of the longest arithmetic progression (AP) of integer squares is equal to three, for example, 1, 25, 49. Recently, Xarles (2011) investigated APs in number fields, and proved the existence of an upper bound $K(d)$ for the maximal length of an AP of squares in a number field of degree d . He shows that $K(2) = 5$, with example $7^2, 13^2, 17^2, \sqrt{409}^2, 23^2$. Cubic fields present difficulty, and $K(3)$ is unknown. There are infinitely many examples of cubic fields containing APs of length 4, but no cubic field is known with a non-trivial AP of length 5. We show why it is very unlikely such a field exists. Cubic fields with such an AP are parametrized by the rational points on three rational curves of genus 8, 9, 9, so by Faltings Theorem, are finite in number. We have been unable to determine the rational points on these curves, but search indicates only trivial solutions. (Received August 16, 2012)

1086-11-302 **Hiren Maharaj*** (hmahara@g.clemson.edu), 8543 Hillside Road, Rancho Cucamonga, CA 91701. *Spaces of Modular forms and Algebraic Geometric codes.*

For $\ell = 2, 3, 5$, the author has show that the space of modular forms $M_{2k}(\Gamma_0(\ell^n))$ is naturally isomorphic to one point Riemann-Roch spaces which arise from the modular curve $X_0(\ell^n)$. Riemann-Roch spaces are used to construct algebraic geometric codes. Thus, in principle, algorithms to construct explicit bases for the spaces of modular forms can in principle also be used to construct explicit bases for algebraic geometric codes. All of this work was done using Elkies' explicit presentation of the above-mentioned modular curves. In the talk I will discuss this work. (Received August 17, 2012)

1086-11-309 **Holley Friedlander, Derek Garton, Beth Malmskog*** (elisabeth.malmskog@coloradocollege.edu), Rachel Pries and Colin Weir. *The a -numbers of Jacobians of Suzuki Curves.*

For $m \in \mathbb{N}$, let S_m be the Suzuki curve defined over $\mathbb{F}_{2^{2m+1}}$. It is well-known that S_m is supersingular, but the p -torsion group scheme of its Jacobian is not known. The a -number is an invariant of the isomorphism class of the p -torsion group scheme. In this talk, I will discuss joint work in which we computed a closed formula for the a -number of S_m using the action of the Cartier operator on H_0 . (Received August 18, 2012)

1086-11-322 **James A. Sellers*** (sellersj@psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *Congruences Modulo Squares of Primes for Fu's k Dots Bracelet Partitions.*

In 2007, Andrews and Paule introduced the family of functions $\Delta_k(n)$ which enumerate the number of broken k -diamond partitions for a fixed positive integer k . In that paper, Andrews and Paule proved that, for all $n \geq 0$, $\Delta_1(2n+1) \equiv 0 \pmod{3}$ using a standard generating function argument. Soon after, Shishuo Fu provided a

combinatorial proof of this same congruence. Fu also utilized this combinatorial approach to naturally define a generalization of broken k -diamond partitions which he called *k dots bracelet partitions*. He denoted the number of k dots bracelet partitions of n by $\mathfrak{B}_k(n)$ and proved various congruence properties for these functions modulo primes and modulo powers of 2. In this note, we extend the set of congruences proven by Fu by proving the following congruences: For all $n \geq 0$,

$$\begin{aligned}\mathfrak{B}_5(10n + 7) &\equiv 0 \pmod{5^2}, \\ \mathfrak{B}_7(14n + 11) &\equiv 0 \pmod{7^2}, \text{ and} \\ \mathfrak{B}_{11}(22n + 21) &\equiv 0 \pmod{11^2}\end{aligned}$$

We also conjecture an infinite family of congruences modulo powers of 7 which are satisfied by the function \mathfrak{B}_7 . This is joint work with Silviu Radu, Research Institute for Symbolic Computation, Austria. (Received August 21, 2012)

1086-11-341 **Pace P. Nielsen*** (pace@math.byu.edu), 318 TMCB, Brigham Young University, Provo, UT 84602. *An approach to odd covering systems.*

It is an open question whether there exists a covering system with all the moduli odd. Using a greedy algorithm one is left with the impression that such a covering system cannot exist. However, an example of Morikawa demonstrates that the greedy algorithm is not the most efficient option available. Using ideas from Gibson, we improve Morikawa's example and suggest another avenue. (Received August 22, 2012)

1086-11-343 **Christelle Vincent*** (cvincent@stanford.edu). *Weierstrass points on the Drinfeld modular curve $X_0(\mathfrak{p})$.*

We consider the Drinfeld setting, which offers analogues for function fields of some aspects of the theory of modular forms, modular curves and elliptic curves. More precisely, we consider the family of modular curves $X_0(\mathfrak{p})$, and we study their Weierstrass points, a finite set of points of geometric interest. These curves are moduli spaces for Drinfeld modules with level structure, which are the objects which in our setting play a role analogous to that of elliptic curves. Previous work of Baker shows that for each Weierstrass point, the reduction modulo \mathfrak{p} of the underlying Drinfeld module is supersingular. We study a modular form W for $\Gamma_0(\mathfrak{p})$ whose divisor is closely related to the set of Weierstrass points. To this end, we first establish a one-to-one correspondence between certain Drinfeld modular forms on $\Gamma_0(\mathfrak{p})$ and forms on the full modular group. In certain cases we can then use knowledge about the action of the Hasse derivatives to compute explicitly a form \widetilde{W} that is congruent to W modulo \mathfrak{p} . This allows us to obtain an analogue of a classical result of Rohrlich's. (Received August 23, 2012)

1086-11-350 **Carl Pomerance*** (carl.pomerance@dartmouth.edu), Mathematics Department, Dartmouth College, Hanover, NH 03755.

Erdős, van der Corput, and the birth of covering congruences. Preliminary report.

In 1849, de Polignac conjectured that every odd number is of the form $2^k + p$, where p is 1 or prime. Just over a century later, in 1950, Erdős and van der Corput independently proved that de Polignac was way off: not only are there infinitely many odd numbers not of the form $2^k + p$, there is in fact a positive proportion of odd numbers not in this form. The Erdős argument is famous because it was here that he introduced covering congruences (a finite set of residue classes with distinct moduli larger than 1 whose union contains every integer). But what of van der Corput's proof? And which proof is a better starting point for obtaining a good lower bound for the density of counterexamples? This largely expository talk will review the two proofs and discuss numerical estimates for the density. (Received August 23, 2012)

1086-11-362 **Mohammad K. Azarian*** (azarian@evansville.edu), Department of Mathematics, University of Evansville, Evansville, IN 47722. *Fibonacci and Lucas Identities as Binomial Sums.*

In this talk we present some prominent identities pertaining to Fibonacci and/or Lucas numbers as binomial sums for rapid numerical calculations. (Received August 25, 2012)

1086-11-374 **Jeongho Park*** (pkskng@naver.com), Department of Mathematics, Pohang University of Science and Technology, San 31 Hyoja Dong, Nam-Gu, Pohang, 790-784, South Korea. *Notes on the Principal Primes of Real Quadratic Number Fields.*

The ideal class group of a number field K has various aspects. Its size measures how far one has to go up to principalize every ideal of K , how small the portion of the principal fractional ideals is, and how small the Dirichlet density of principal primes is. Simple observation suggests that knowing a single principal prime and

its conjugate is almost equivalent to knowing the fundamental unit and successively to knowing a precise bound for the class number. This translates the problem of ideal class group to one about principal prime ideals over a fixed rational prime p . In this talk an explicit construction will be given that covers all real quadratic number fields K whose prime ideals lying over p are principal. (Received August 27, 2012)

1086-11-380 **Sarah Chisholm, Alyson Deines and Ling Long*** (11637@cornell.edu), 408 Malott Hall, Cornell University, Ithaca, NY 14850, and **Gabriele Nebe and Holly Swisher.**
Ramanujan-type Supercongruences and complex multiplications on elliptic curves.

In Ramanujan's work on modular equations and approximation to π , he gave a list of formulas for $1/\pi$ in terms of values of special hypergeometric series. It is discovered by van Hamme and later formulated more explicitly by Zudilin that the corresponding truncated hypergeometric series satisfy surprising congruence properties. In this talk, we will discuss some recent progress regarding these so-called Ramanujan-type Supercongruences via the arithmetic of complex multiplications on elliptic curves. (Received August 27, 2012)

1086-11-386 **Nathan C. Ryan*** (nathan.ryan@bucknell.edu) and **David W. Farmer.** *Evaluating L-functions with few known coefficients.*

We address the problem of evaluating an L-function; in particular we are interested in finding the first few zeros of an L-function when only a small number of Dirichlet coefficients are known. We use the approximate functional equation in a new way and find that it is possible to evaluate the L-function more precisely than one would expect from the standard approach. The method, however, requires considerably more computational effort to achieve a given accuracy than would be required if more Dirichlet coefficients were available. (Received August 27, 2012)

1086-11-437 **Sungmun Cho*** (moonigmi@gmail.com), 567 Lake Hall, 360 Huntington Avenue, Boston, MA 02115. *Group schemes and local densities of quadratic lattices in residue characteristic 2.*

The celebrated Smith-Minkowski-Siegel mass formula expresses the mass of a quadratic lattice (L, Q) as a product of local factors, called the local densities of (L, Q) . This mass formula is an essential tool for the classification of integral quadratic lattices. In this talk, I will explain the local density formula by observing the existence of a smooth affine group scheme \underline{G} over \mathbb{Z}_2 with the generic fiber $\text{Aut}_{\mathbb{Q}_2}(L, Q)$, which satisfies $\underline{G}(\mathbb{Z}_2) = \text{Aut}_{\mathbb{Z}_2}(L, Q)$. This method works for any unramified finite extension of \mathbb{Q}_2 . Consequently, This provides the long awaited proof for the local density formula of Conway and Sloane and its generalization to unramified finite extensions of \mathbb{Q}_2 . As an example, I give the mass formula for the integral quadratic form $Q_n(x_1, \dots, x_n) = x_1^2 + \dots + x_n^2$ associated to a number field k which is totally real and such that the ideal (2) is unramified over k . (Received September 01, 2012)

1086-11-455 **Avraham Bourla*** (abourla@smcm.edu), Department of Mathematics, St. Mary's College of Maryland, 18952 E. Fisher Rd, Saint Mary's City, MD 20686. *Symmetry in the Sequence of Approximation Coefficients.*

Let $\{a_n\}_1^\infty$ and $\{\theta_n\}_0^\infty$ be the sequences of partial quotients and approximation coefficients for the regular continued fraction expansion of an irrational number in the unit interval. We are going to find a real valued function f on two variables, such that $a_{n+1} = f(\theta_{n-1}, \theta_n) = f(\theta_{n+1}, \theta_n)$. In tandem with a formula due to Dajani and Kraaikamp, we will write $\theta_{n\pm 1}$ in terms of $(\theta_{n\mp 1}, \theta_n)$, revealing an elegant symmetrical structure in this classical sequence. In particular, this will enable us to recover the entire sequence from a pair of consecutive terms. (Received September 03, 2012)

1086-11-466 **Alina Bucur, Chantal David, Brooke Feigon and Matilde Lalin***, mlalin@dms.umontreal.ca, and **Kaneenika Sinha.** *Distribution of zeta zeroes of Artin-Schreier curves.*

We study the distribution of the zeroes of the zeta functions of the family of Artin-Schreier curves over \mathbb{F}_q when q is fixed and the genus goes to infinity. (Received September 03, 2012)

1086-11-468 **William Abram** (abramwc@umich.edu) and **Jeffrey C. Lagarias*** (lagarias@umich.edu). *Intersections of Multiplicative Translates of 3-adic Cantor sets.*

Erdős raised the question of when the ternary expansion of 3^n omits the digit 2. This is believed to happen finitely often, but seems intractable. We investigate the question of the Hausdorff dimension of the set of 3-adic integers λ having the property that infinitely many $2^n\lambda$ omit the digit 2 in their 3-adic expansion. This leads to study of intersections of multiplicative translates of 3-adic Cantor sets S of the form $S \cap MS$, where M is an integer. The structure of such sets can be explicitly described in any individual case, and the Hausdorff

dimension computed. We report on explicit examples, some infinite families that are analyzable, and obtain bounds relevant to the original question. (Received September 03, 2012)

1086-11-486 **Larry J. Gerstein*** (gerstein@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106-3080. *Unimodular lattices*. Preliminary report. The talk will discuss the classification problem for unimodular lattices over the rational integers. Special attention will be given to the possible relevance of so-called "nearly unimodular" lattices of codimension one primitively represented by a given lattice. (Received September 04, 2012)

1086-11-494 **Pete L. Clark*** (pete@math.uga.edu). *Euclidean Ideals and Euclidean Forms*. Let R be a normed domain with fraction field K . Let D be a finite-dimensional alternative K -algebra, let A be an R -order in D , and let I be an ideal in R . Following H. Lenstra, we introduce the concept of I being a **Euclidean ideal**. An ideal is Euclidean iff a certain associated norm form is a **Euclidean form**. When D is a quadratic algebra (e.g. a quaternion or octonion algebra), we get a Euclidean quadratic form in the sense of our previous work.

When R is a Dedekind domain, Lenstra showed that the existence of a Euclidean ideal forces the Picard group of R to be cyclic; he also showed (e.g.) that if the ring of integers of a quadratic field admits a Euclidean ideal, then its Picard group has order at most 2. We present a non-commutative (but associative!) analogue of these results: in particular, under suitable hypotheses, if a maximal order in a quaternion algebra admits a Euclidean ideal it has class number at most 2. We use this result to rederive Fitzgerald's classification of Euclidean ideals in definite quaternion orders over \mathbb{Z} . (Received September 05, 2012)

1086-11-508 **Saikat Biswas*** (sbiswas33@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332-0160. *Tamagawa Torsors of an Abelian Variety*.

For an abelian variety A defined over a number field K , we define the Tamagawa torsors of A at a prime v of K to be the set of A -torsors defined over the completion K_v of K at v that are split by an unramified extension. It turns out the set of such torsors is finite, having cardinality equal to the Tamagawa number of A at v (which also prosaically explains the terminology). In this talk, we will discuss some arithmetic properties of the Tamagawa torsors including its relation to the Selmer group and the Shafarevich-Tate group of A , as well as to the Brauer group of K_v . Finally, following Mazur's theory of visibility, we will give conditions under which non-trivial Tamagawa torsors of A may be 'visualized' as Mordell-Weil points on another abelian variety B also defined over K . We will also explain how our visibility theorem provides theoretical evidence for the Birch and Swinnerton-Dyer Conjecture. (Received September 25, 2012)

1086-11-512 **Hieu D Nguyen*** (nguyen@rowan.edu), Department of Mathematics, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028, and **Douglas Taggart**. *Mining the OEIS: Ten Experimental Conjectures*.

This talk describes recent progress made by Project Eureka, an experimental mathematics project aimed at mining the Online Encyclopedia of Integer Sequences (OEIS) for new mathematical identities. A summary of our results will be presented, along with ten new experimental conjectures. (Received September 05, 2012)

1086-11-515 **Carl Pomerance***, Mathematics Department, HB 6188, Hanover, NH 03755. *Some statistical problems concerning the arithmetic functions σ and φ* . Preliminary report.

Let σ be the sum-of-divisors function and let φ be Euler's function. Some famously hard problems: Are there infinitely many solutions to $n \mid \sigma(n)$ or any odd solutions $n > 1$? Are there any composite solutions to $\varphi(n) \mid n-1$? Short of solving these and similar problems, one can perhaps move to more tractable ground by framing them statistically; that is, as counting problems. For example, how many composite solutions to $\varphi(n) \mid n-1$ are there in $[1, x]$ as x grows? A small upper bound for such a count can then be regarded as progress towards the possibility that there are no solutions. In this talk I will discuss recent developments with problems of this type representing joint work in several papers with A. Anavi, F. Luca, P. Pollack, and E. Treviño. (Received September 05, 2012)

1086-11-525 **Lisa Berger, Chris Hall, René Pannekoek, Jennifer Park, Rachel Pries, Shahed Sharif, Alice Silverberg*** (asilverb@uci.edu) and **Douglas Ulmer**. *Explicit points on a family of Jacobians of superelliptic curves over global function fields*. Preliminary report.

In a project initiated at an AIM workshop, we are studying arithmetic questions about the Jacobian variety of the curve $y^r = x^{r-1}(x+1)(x+t)$ over fields of the form $K_d = \mathbb{F}_p(\mu_d, t^{1/d})$ where $d = 1 + p^f$ and r divides d .

In particular, we find explicit rational points and rank $(d-2)(r-1)$, generalizing earlier work of Ulmer on the Legendre elliptic curve. This talk will give a report on our progress. (Received September 05, 2012)

1086-11-534 **Steven J Miller*** (sjm1@williams.edu), 18 HOXSEY ST, Williamstown, MA 01267.
Low-lying zeros of $GL(2)$ L -functions.

We report on recent progress on the n -level densities of low-lying zeros of $GL(2)$ L -functions. We derive an alternate formula for the Katz-Sarnak determinant expansions for test functions with large support that facilitates comparisons between number theory and random matrix theory in orthogonal, symplectic, and unitary settings. Using combinatorics, generating functions, and analysis, we prove these formulas hold and increase the region where number theory and random matrix theory can be shown to agree for holomorphic cuspidal newforms. We also investigate a natural arithmetic conjecture that allows us to derive formulas for test functions with even larger support. Additionally, we study the Katz-Sarnak conjecture for the infinite family of Maass forms. Similar to the holomorphic case, the underlying symmetry group is orthogonal, both when the level tends to infinity or in the harder case when the level is fixed. This is joint work with Levent Alpoge, Geoff Iyer and Nicholas Triantafillou. (Received September 06, 2012)

1086-11-553 **Joshua Harrington***, Department of Mathematics, University of South Carolina, 1523 Greene Street, Columbia, SC 29208, and **Michael Filaseta**. *A polynomial investigation inspired by work of Schinzel and Sierpiński.*

In 1960 Sierpiński proved that there are infinitely many odd positive integers k such that $k \cdot 2^n + 1$ is composite for all positive integers n . A polynomial variation of Sierpiński's result has been investigated by several people. More specifically, the question has been asked, for which integers d does there exist a polynomial $f(x) \in \mathbb{Z}[x]$ with $f(1) \neq -d$ such that $f(x) \cdot x^n + d$ is reducible over the rationals for all positive integers n . In 1967 Schinzel proved that there exists such a polynomial for $d \equiv 0 \pmod{12}$. This result was then extended in 2002 by Michael Filaseta who proved that such a polynomial exists for $d \equiv 0 \pmod{4}$. It was then shown in 2009 by Lenny Jones that one can find such a polynomial for infinitely many $d \equiv 6 \pmod{12}$. In this talk we further investigate this problem and improve upon previously known results. (Received September 06, 2012)

1086-11-557 **Carlos De la Mora*** (cdelamor@math.purdue.edu). *Explicit Plancherel measure for $PGL_2(F)$ over a p -adic field.*

Computing an explicit Plancherel measure for a reductive group over the p -adic field has been a difficult task. A general theory has been developed in a joint paper by G.Henniart, C.Bushnell and P.Kutzko on computation of the Plancherel measure. The main ideas are to decompose \widehat{G} into a union $\widehat{G} = \cup_{\mathfrak{s} \in \mathfrak{B}(G)} G(\mathfrak{s})$ where elements in $\mathfrak{B}(G)$ correspond to Bernstein components. We then know that we can identify each set $G(\mathfrak{s})$ with the unitary dual of a Hecke algebra $\mathcal{H}(G, \lambda)$ where (J, λ) is an \mathfrak{s} -type in the sense of Bushnell and Kutzko. Then the Hecke algebras can be seen as Hilbert algebras and they have a corresponding Plancherel measure that is related to the Plancherel measure in \widehat{G} in a very explicit way. I will approach the problem of computing the Plancherel measure for $PGL_2(F)$ using the method described above. (Received September 06, 2012)

1086-11-566 **Krishnaswami Alladi*** (alladi@ufl.edu), Department of Mathematics, 358 Little Hall, University of Florida, Gainesville, FL 32606. *Analysis of a generalized Lebesgue identity in Ramanujan's Lost Notebook.*

We analyze a two parameter q -series identity in Ramanujan's Lost Notebook that generalizes the product part of the fundamental one parameter Lebesgue identity. From reformulations of this two parameter identity, we deduce new partition theorems including variants of the Gauss triangular numbers identity and Euler's pentagonal numbers theorem. We discuss connections with a partial theta identity of Ramanujan (also in the Lost Notebook) and with several classical results such as those of Sylvester and Göllnitz-Gordon. (Received September 07, 2012)

1086-11-568 **Patrick X Rault*** (rault@geneseo.edu), 326C South Hall, Department of Mathematics, SUNY Geneseo, Geneseo, NY 14454. *On uniform bounds for lattice points in plane regions and for rational points on rational curves of arbitrary degree.*

We use rational parametrizations to make progress on an open question about counting rational points on plane curves. Heath-Brown proved that for any $\epsilon > 0$ the number of rational points of height at most B on a degree d plane curve is $O_{\epsilon, d}(B^{2/d+\epsilon})$ (the implied constant depends on ϵ and d). It is known that Heath-Brown's theorem is sharp apart from the ϵ , but in certain cases the bound has been improved to $\epsilon = 0$. The open question is whether or not the bound with $\epsilon = 0$ holds in general. We resolve this question for degree d curves with nice resultant and discriminant. (Received September 07, 2012)

1086-11-569 **Lenny Fukshansky** and **Kathleen Petersen*** (petersen@math.fsu.edu). *Well-Rounded Ideal Lattices.*

A lattice of full rank in a Euclidean space is called well-rounded if its set of minimal vectors spans the whole space. Well-rounded lattices are important in discrete optimization, in particular in the investigation of sphere packing, sphere covering, and kissing number problems, as well as in coding theory. I will discuss the well-rounded property in the context of lattices associated to rings of integers of number fields and sub-lattices associated to ideals. I'll answer the question of which of these integer lattices are well-rounded. I'll also show the existence of infinitely many well-rounded ideal lattices in the quadratic case. (Received September 07, 2012)

1086-11-582 **Andrew V. Sills*** (asills@georgiasouthern.edu) and **Doron Zeilberger**. *Rademacher's infinite partial fractions conjecture is (almost certainly) false.*

A partition of n is a representation of n as a sum of positive integers where the order of summands is considered irrelevant. Let $p_m(n)$ denote the number of partitions of n with at most m summands. The generating function of $p_m(n)$ is

$$f_m(x) = \sum_{n \geq 0} p_m(n) x^n = \frac{1}{(1-x)(1-x^2) \cdots (1-x^m)}.$$

For any fixed m , it is theoretically straightforward to find the partial fraction decomposition of the generating function for $p_m(n)$. Rademacher made a beautiful and natural conjecture concerning the limiting behavior of the coefficients in the partial fraction decomposition of $f_m(x)$ as $m \rightarrow \infty$, which was published posthumously in 1973. Little progress had been made on this conjecture until just recently, perhaps in large part due to the difficulty of actually calculating Rademacher's coefficients for even moderately large values of m . Zeilberger and I found and implemented a fast algorithm for computing Rademacher's coefficients, and as a result, it now seems quite clear that Rademacher's conjecture is almost certainly *false*! We present some new theorems and conjectures concerning the behavior of Rademacher's coefficients. (Received September 07, 2012)

1086-11-632 **Benjamin D. Sokolowsky*** (bds021@bucknell.edu), 701 Moore Ave c1737, Lewisburg, PA 17837, **Amy G. VanHooft** (agvanhooft@rochester.rr.com), 482 West Ave, Brockport, NY 14420, **Rachel M. Volkert** (volkertr@uni.edu), 315 North Guilford Street, Sumner, IA 50674, and **Clifford A. Reiter** (reiterc@lafayette.edu), Department of Mathematics, Lafayette College, Easton, PA 18042. *An Infinite Family of Perfect Parallelepipeds.*

A perfect parallelepiped has edges, face diagonals, and body diagonals all of integer length. We prove the existence of an infinite family of dissimilar perfect parallelepipeds with two nonparallel rectangular faces. We also show that we can obtain perfect parallelepipeds of this form with the angle of the non-rectangular face arbitrarily close to 90° . Finally, we discuss the implications which this family has on the famous open problem concerning the existence of a perfect cuboid. This leads to two conjectures that would imply no perfect cuboid exists. (Received September 09, 2012)

1086-11-635 **Kevin G Hare***, kghare@uwaterloo.ca, and **Michael J Mossinghoff**. *Sporadic Reinhardt polygons.*

Let n be a positive integer, not a power of two. A *Reinhardt polygon* is a convex n -gon that is optimal in three different geometric optimization problems: it has maximal perimeter relative to its diameter, maximal width relative to its diameter, and maximal width relative to its perimeter. For almost all n , there are many Reinhardt polygons with n sides, and many of them exhibit a particular periodic structure. While these periodic polygons are well understood, for certain values of n , additional Reinhardt polygons exist that do not possess this structured form. We call these polygons *sporadic*. We will discuss these sporadic Reinhardt polygons. (Received September 10, 2012)

1086-11-641 **David J. Gryniewicz*** (diambri@hotmail.com), Institut für Mathematik, Heinrichstrasse 36, 8010 Graz, Austria, and **Alfred Geroldinger**. *The Large Davenport Constant for Non-Abelian Groups.*

By a sequence over a group G , we mean a finite sequence of terms from G which is unordered, and we say that it is product-one if its terms can be ordered so that their product is the identity. The product-one sequences form a monoid called the Block monoid of G . The *small Davenport constant* $d(G)$ is the maximal integer ℓ such that there is a sequence over G of length ℓ which has no nontrivial, product-one subsequence. The *large Davenport constant* $D(G)$ is the maximal length of a minimal product-one sequence—this is the maximal length of an atom in the Block monoid over G , i.e., the maximal length of a product-one sequence which cannot be factored into two nontrivial, product-one subsequences. It is easily observed that $d(G) + 1 \leq D(G)$, and if G is abelian, then

equality holds and the constant $D(G)$ is also known to be equal to the Noether constant $\beta(G)$ from Invariant Theory. However, for non-abelian groups, these constants can all differ significantly.

The goal of this talk is present various upper bounds for $D(G)$ in the non-abelian setting. In the case when G possesses a cyclic, index 2 subgroup, we will present an exact value. (Received September 10, 2012)

1086-11-645 **Rachel M. Davis*** (rdavis@math.wisc.edu). *On the Images of Outer Galois Representations Associated to Elliptic Curves*. Preliminary report.

For ℓ -adic representations of the absolute Galois group associated to elliptic curves, much is understood about the sizes of the images and about the conjugacy invariants of the images of Frobenius elements. On the other hand, much less is known about the outer Galois representations associated to elliptic curves. These are representations from the absolute Galois group to an outer automorphism group of a free pro- ℓ group.

The goal of this research is to take a first step in understanding more concretely Galois representations to automorphism groups of non-abelian groups. Let E be a semistable elliptic curve over \mathbb{Q} with good supersingular reduction at 2. Associated to E , there is a Galois representation to a certain subgroup of the automorphism group of a metabelian group. I show that there is a Galois representation surjecting to this subgroup (with the right ramification). Then, I compute some conjugacy invariants for the images of the Frobenius elements. This will give rise to new arithmetic information analogous to traces of Frobenius for the ℓ -adic representation. (Received September 10, 2012)

1086-11-652 **Andrew D Bridy*** (bridy@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706. *Transcendence of the Artin-Mazur Zeta Function for Polynomial Maps in Positive Characteristic*.

The Artin-Mazur zeta function of a discrete dynamical system is a generating function that captures information about all periodic points of all periods. I show that some simple polynomial self-maps of $\mathbb{A}^1(\mathbb{F}_p)$ have transcendental zeta functions. (Received September 10, 2012)

1086-11-658 **Youngsoo Kim*** (kimy@mytu.tuskegee.edu), Department of Mathematics, Kenney Hall, Suite 70-365, Tuskegee University, Tuskegee, AL 36088. *Semistability of Root Lattices And Perfect Lattices*.

I will present the definition of canonical filtration and semistability of a lattice from a version of reduction theory of lattices. Then we investigate the semistability of root lattices and perfect lattices. It turns out that all irreducible root lattices are semistable and perfect lattices of dimension at most 7 are semistable. But there are rare cases of unstable perfect lattices in higher dimensions. For example, there is a unique lattice that is not semistable among 10916 perfect lattices in dimension 8. (Received September 10, 2012)

1086-11-662 **Anna Haensch*** (ahaensch@wesleyan.edu), Dept. of Math and Computer Science, Science Tower 655, 265 Church St., Middletown, CT 06457. *On almost universal ternary inhomogeneous quadratic polynomials*.

A fundamental question in the study of integral quadratic forms is the representation problem which asks for an effective determination of the set of integers represented by a given quadratic form. A related and equally interesting problem is the representation of integers by inhomogeneous quadratic polynomials. An inhomogeneous quadratic polynomial is a sum of a quadratic form and a linear form; it is called *almost universal* if it represents all but finitely many positive integers. This talk gives a characterization of almost universal ternary inhomogeneous quadratic polynomials, given by

$$H(x) = \frac{1}{p^\alpha} [2B(\nu, x) + Q(x)],$$

where p is prime, $\alpha > 0$, Q is the quadratic map associated to a positive definite quadratic lattice N , and ν is a vector not in N . Imposing some mild arithmetic conditions, we will rely on the theory of quadratic lattices and primitive spinor exceptions to give a list of global conditions on ν and N , under which $H(x)$ is almost universal. In particular, we will present some examples of almost universal quadratic polynomials, given by mixed sums of squares and polygonal numbers. (Received September 10, 2012)

1086-11-672 **Lane E Bloome*** (lbloome@millikin.edu), Millikin University, Decatur, IL 62522, **Marcella Noorman** (marcella.noorman@pop.belmont.edu), Belmont University, Nashville, TN 37212, and **Justin Ferguson** (jmfergus@keuka.edu), Keuka College, Keuka Park, NY 14478. *Appending digits to Sierpiński, Riesel and Riesel-Sierpiński numbers*.

In 1960, Sierpiński proved that there are infinitely many odd numbers k such that $k2^n + 1$ is composite for all $n \in \mathbb{N}$. In 2011, Jones and White investigated the effects of appending sequences of digits to the left and to the right of positive integers. Using a technique pioneered by Paul Erdős, we construct arithmetic progressions of

Sierpiński numbers (and other numbers with similar properties) that generate sequences of composite numbers upon repeatedly appending digits $d \in \{1, 3, 7, 9\}$ to the right. We also investigate cases in which Sierpiński numbers generate sequences of Sierpiński numbers upon repeated appending of digits. (Received September 10, 2012)

1086-11-681 **Chantal David*** (cdavid@mathstat.concordia.ca), **Alina Bucur** (alina@math.ucsd.edu), **Brooke Feigon** (bfeigon@ccny.cuny.edu), **Matilde Lalin** (mlalin@dms.umontreal.ca) and **Kaneenika Sinha** (kaneenika@gmail.com). *Zeta zeroes of Artin-Schreier curves.*

We study the distribution of the zeroes of the zeta functions in the family of Artin-Schreier curves over the finite fields \mathbb{F}_q , when q is fixed and the genus goes to infinity. More precisely, we show that the distribution of the properly normalized zeroes in intervals of the unit circle follows a Gaussian distribution. This is done by computing the normalized moments of certain approximations of the number of zeroes in intervals given by the Beurling-Selberg polynomials.

This is joint work with A. Bucur, B. Feigon, M. Lalin and K. Sinha. (Received September 11, 2012)

1086-11-685 **Vorropan Chandee** (vorrapan@gmail.com), **Chantal David*** (cdavid@mathstat.concordia.ca), **Dimitris Koukoulopoulos** (dimkouk@gmail.com) and **Ethan Smith** (ethansmith@gmail.com). *Elliptic curves with prescribed groups over finite fields.*

Let $G_{m,k} := \mathbb{Z}/m\mathbb{Z} \times \mathbb{Z}/mk\mathbb{Z}$ be an abelian group of rank 2 and order $N = mk^2$. When does there exist a finite field \mathbb{F}_p and an elliptic curve E/\mathbb{F}_p such that $E(\mathbb{F}_p) \simeq G_{m,k}$? It was conjectured by Banks, Pappalardi and Shparlinski that this happens with density 0 if the group is “too split”, namely if $k \ll (\log m)^{2-\epsilon}$, and with density 1 if $k \gg (\log m)^{2+\epsilon}$. We prove in this talk that the first part of the conjecture holds for the whole range of m and k , and that the second part holds for the limited range $m \leq k^{1/4+\epsilon}$. We also show that G occurs with positive density for a larger range.

This is joint work with F. Chandee, D. Koukoulopoulos and E. Smith. (Received September 11, 2012)

1086-11-713 **Ken McMurdy*** (kcmurdy@ramapo.edu), Department of Mathematics (TAS), Ramapo College of New Jersey, 505 Ramapo Valley Rd., Mahwah, NJ 07430. *A New Algorithm for Computing Endomorphism Rings of Supersingular Elliptic Curves.*

It is well known from the work of M. Deuring that there is a one-to-one correspondence between endomorphism rings of supersingular elliptic curves mod p and the maximal orders in the quaternion algebra $\mathbb{Q}_{p,\infty}$ to which they are isomorphic. Most algorithms for making the isomorphisms or even the correspondence explicit, however, inevitably involve some “blind searching” on either the quaternion side, the elliptic curve side, or both. Here we describe an algorithm which is relatively easy to implement and contains almost no searching. The key idea is to apply W. Waterhouse’s theory of kernel ideals, as developed in his Harvard thesis. (Received September 11, 2012)

1086-11-736 **Jeremy Rouse***, Department of Mathematics, Wake Forest University, Winston-Salem, NC 27109. *Quadratic forms representing all odd positive integers.*

We discuss an analytic method for bounding the coefficients of cusp forms that appear in the decomposition of theta series of quaternary quadratic forms. This method relies on the theory of Rankin-Selberg L -functions to compute Petersson inner products. Using this method we prove that if D is a fundamental discriminant and Q is a positive-definite quadratic form with discriminant D , then the largest locally represented integer that is not represented by Q is $\ll D^{2+\epsilon}$. This method was one of four employed to give a conditional proof that a positive-definite integer-valued quadratic form representing the odd numbers from 1 to 451 represents all odd numbers. (Received September 11, 2012)

1086-11-748 **Geremias Polanco E.***, 401 W. Chesnut St, Bloomington, IL 61701, and **Daniel Schultz** and **Alexandru Zaharescu**. *Continuous Distribution Arising from the Three Gap Theorem.*

The well known Three Gap Theorem states that for α irrational, there are at most three gap sizes in the sequence of fractional parts $\{\alpha n\}_{n < N}$. The main discovery in this talk is that if we average over a short interval $[\beta, \beta + \eta]$, the distribution becomes continuous. Moreover, this continuous distribution is universal in the sense that it is the same for any α and any interval around β . Under these circumstances one would expect that the above averaging process would introduce enough randomness in the sequence so that the limiting distribution would be Poissonian. We will prove that, surprisingly, this is not the case. (Received September 12, 2012)

1086-11-764 **Stephan Ramon Garcia*** (stephan.garcia@pomona.edu), Department of Mathematics, Pomona College, 610 N. College Ave., Claremont, CA 91711. *Supercharacter theory and Ramanujan's sum.*

We demonstrate that many of the fundamental algebraic properties of Ramanujan sums can be deduced using the theory of *supercharacters*, recently developed by Diaconis-Isaacs and André to study the representation theory of the unipotent matrix groups $U_n(q)$. This new machinery frequently yields one-line proofs of difficult identities and provides many novel formulas. We also discuss generalizations which encompass Gauss and Kloosterman sums, as well as several related classes of exponential sums which produce visually striking patterns. (Received September 12, 2012)

1086-11-773 **Kiran S. Kedlaya***, Department of Mathematics, University of California, San Diego, 9500 Gilman Drive #0112, La Jolla, CA 92093. *Towards global (φ, Γ) -modules and comparison isomorphisms.*

This is a followup to the talk by Chris Davis in the same session. The central result of p -adic Hodge theory is the comparison isomorphism linking two different cohomology theories for algebraic varieties over p -adic fields, namely étale cohomology with p -adic coefficients and algebraic de Rham cohomology. One can formally restate the comparison isomorphism as a third cohomology theory for p -adic varieties with values in the category of (φ, Γ) -modules (certain modules over a p -adic period ring equipped with extra monoid actions). This suggests the possibility of developing a more global theory of (φ, Γ) -modules providing a target category for a cohomology functor on the category of algebraic varieties over number fields. The ultimate goal would be to recover global étale cohomology, L -functions, and p -adic L -functions from the (φ, Γ) -module. Besides some speculations on the shape of such a theory, we provide a modest concrete step in the right direction by showing how to add one extra structure to the usual p -adic (φ, Γ) -modules: a descent datum on de Rham cohomology from a p -adic field to a number field. (Received September 12, 2012)

1086-11-775 **Alina Bucur*** (alina@math.ucsd.edu), Department of Mathematics, University of California at San Diego, 9500 Gilman Dr #0112, La Jolla, CA 92093, and **Ling Hoeschler, Renate Scheidler** and **Melanie Matchett Wood**. *Parametrizing D_4 covers over finite fields.*

This talk will report on the WIN2 project of my group. We will focus on the parametrization of D_4 covers of the projective line over a finite field by tuples of quadratic forms. (Received September 12, 2012)

1086-11-778 **Bryden R Cais*** (cais@math.arizona.edu), Dept of Mathematics, 617 N. Santa Rita Ave, Tucson, AZ 85721. *Iwasawa theory of the Igusa tower.*

We study the structure of the p -torsion of the \mathbf{Z}_p -tower of Jacobians of Igusa curves over \mathbf{F}_p , and we prove control theorems for the étale and multiplicative parts of these group schemes. (Received September 12, 2012)

1086-11-781 **Christopher Davis*** (davis@math.uci.edu), Dept. of Mathematics, UC Irvine, Irvine, CA 92697. *Base rings for global (φ, Γ) -modules.*

This talk is about adapting to number fields a theory which has been used to study cohomology theories of varieties over p -adic fields. We first recall the existing theory. Let X be a variety over the field of p -adic numbers, \mathbb{Q}_p . Under suitable assumptions, the associated étale cohomology groups with p -adic coefficients live in the category of \mathbb{Z}_p -modules equipped with a continuous action of the absolute Galois group $G_{\mathbb{Q}_p}$. The theory of (φ, Γ) -modules concerns certain equivalent categories, in which the objects are again modules equipped with certain actions. In the new category the actions come from simpler objects than $G_{\mathbb{Q}_p}$, but the base rings for the modules are much more complicated than \mathbb{Z}_p . In this talk we will construct a global analogue of these base rings, which makes use of big Witt vectors, overconvergence conditions, and inverse limits under the Witt vector Frobenius maps. We will indicate why this is a reasonable analogue. This is joint work with Kiran Kedlaya, who will be giving a follow-up talk. (Received September 12, 2012)

1086-11-787 **Lenny Fukshansky, Glenn Henshaw, Philip Liao, Matthew Prince, Xun Sun*** (foxfur_32@hotmail.com) and **Samuel Whitehead**. *On integral and ideal well-rounded lattices.*

We give a characterization of ideal well-rounded lattices in the plane and show that a positive proportion of real and imaginary quadratic number fields contains ideals giving rise to well-rounded lattices. This extends some previous results of L. Fukshansky and K. Petersen. Our main tool is a parameterization of similarity classes of integral well-rounded lattices in the plane by solutions of certain Pell-type Diophantine equations. (Received September 12, 2012)

1086-11-800 **Wolfgang A Schmid*** (schmid@math.univ-paris13.fr). *Bounding some constants in quantitative non-unique factorization theory via coding theory, and generalizations.*

When determining the asymptotics of the counting function of all principal ideals that are the product of at most k irreducible elements, in a maximal order of an algebraic number field (and the same is true in other or more general situations), a certain generalization of the Davenport constant arises; this is a result due to Halter-Koch. This constant is a zero-sum constant and depends on the class group only.

We discuss how for the case that the class group is an elementary 2-group, results from coding theory can be used in order to obtain bounds (and sometimes the exact value) on the numerical value of this constant; this is joint work with Plagne.

Time permitting, recent generalizations and related questions are discussed. (Received September 12, 2012)

1086-11-808 **Enver Ozdemir***, Division of Mathematical Sciences, Nanyang Technological University, Singapore, Singapore. *Primality Test with Singular Hyperelliptic Curves.*

In this work, we describe new methods for primality test. The methods rely on the extension of the Mumford representation for singular hyperelliptic curves. (Received September 13, 2012)

1086-11-838 **Joshua Cooper, Joshua Harrington and Daniel White*** (white54@mailbox.sc.edu). *Strongly Coloring Pythagorean Triples using Covering Systems.*

It's easily shown that there exist $O(\log n)$ -colorings of $[n]$ such that no Pythagorean triple $\leq n$ is monochromatic. One may consider the analogous problem of finding the number of colors required so that each Pythagorean triple $\leq n$ is strongly colored. In particular, we investigate this number if one allows at most a vanishing proportion of Pythagorean triples $\leq n$ to fail to have such a coloring. Covering systems are used as a main tool. (Received September 13, 2012)

1086-11-842 **Hatice Sahinoglu*** (haticesahinoglu@gmail.com). *On the Independence of Heegner Points.*

In this talk we are going to describe the construction of a particular set of algebraic points, which will be called as Heegner Points, on elliptic curves. Then we will investigate under which constraints Heegner points are independent. We give a sufficient condition on the class numbers of distinct quadratic imaginary fields so that on a given CM elliptic curve over \mathbb{Q} with fixed modular parametrisation, the Heegner points associated to (the maximal orders of) the quadratic imaginary fields are linearly independent. This result extends the results of Rosen and Silverman from the non-CM elliptic curves to the CM ones. We will also show how to generalize the independence of Heegner points associated to maximal orders result to the Heegner points associated to orders of an arbitrary fixed conductor of quadratic imaginary fields. We will look at independence of Heegner points arising from Shimura curve parametrisation and p -adic uniformisations. Finally, if time permits, we will build tools to investigate the independence of the Heegner points on higher dimensional abelian varieties. (Received September 13, 2012)

1086-11-889 **Ana Caraiani*** (caraiani@math.uchicago.edu), 1 W Superior St, Apt 1307, Chicago, IL 60654. *Local global compatibility and monodromy.*

The global Langlands correspondence for GL_n associates to a cuspidal automorphic representation of GL_n satisfying certain technical conditions a number theoretic object, namely a Galois representation. This is known in many cases to be compatible with the local Langlands correspondence due to Harris-Taylor and Henniart. This compatibility generalizes the classical compatibility between local and global class field theory. In the case of GL_n , I will explain how to prove the compatibility for monodromy operators, when the automorphic representation is regular-algebraic and conjugate-self dual. (Received September 14, 2012)

1086-11-907 **Rebecca Bellovin, Sharon Anne Garthwaite and Ekin Ozman***, ozman@math.utexas.edu, and **Rachel Pries, Cassandra Williams and Hui June Zhu.** *Newton and Hodge Polygons for a Variant of the Kloosterman Family*

In this talk we investigate the behavior of Hodge polygons for the L -functions of a family of exponential sums of Laurent polynomial f in $\mathbb{F}_q[x_1, \dots, x_n, (x_1 \cdots x_n)^{-1}]$, where f deforms the diagonal polynomial $f_0 = x_1^m + \cdots + x_n^m$. We explicitly compute the Hodge numbers for such deformations in lower dimensions. Using these computations, one can determine the corresponding Hodge polygon which is a lower bound for the Newton polygon. (Received September 15, 2012)

- 1086-11-909 **Victor D Luo*** (vd11@williams.edu), 4408 Jensen Place, Fairfax, VA 22032, and **Amanda Bower** and **Steven J Miller**. *Generalized Sum and Difference Sets and d -dimensional Modular Hyperbolas*.

Many problems in additive number theory, such as Fermat's last theorem and the Twin Prime conjecture, can be understood by examining sums of a set with itself. A finite set $A \subset \mathbb{Z}$ is considered sum-dominant if $|A + A| > |A - A|$. Although it may seem that most sets are difference-dominated since addition is commutative and subtraction is not, by controlling the fringes Martin and O'Bryant in 2007 proved a positive percentage are sum-dominant.

To see interesting behavior, the above results suggest looking at modular sets, as there are no fringes. Good choices arise from modular hyperbolas, $H_d(1; n) := \{(x_1, \dots, x_d) : x_1 \cdots x_d \equiv 1 \pmod{n}\}$. In 2009, Eichhorn, Khan, Stein, and Yankov investigated the sizes of $\{x + x^{-1}\}$ and $\{x - x^{-1}\}$ where $x \in H_2(1; n)$. They proved results about the relative sizes of these restricted sum sets and difference sets, and also proved subsets of \mathbb{Z}_n were in fact sum-dominated at least 84% of the time. We extend their results to d -dimensional modular hyperbolas. The key ingredients for the counting are Kloosterman sums, Hensel's lemma, and congruence theory. (Received September 15, 2012)

- 1086-11-913 **Rebecca Bellovin, Sharon Anne Garthwaite, Ekin Ozman, Rachel Pries*** (pries@math.colostate.edu), **Cassandra Williams** and **Hui June Zhu**. *Newton polygons for a variant of the Kloosterman family*.

Given a Laurent polynomial f in n variables defined over a finite field of characteristic p , one can associate to it the L -function of the exponential sum of f . Under a non-degeneracy condition, the L -function or its reciprocal is a polynomial, and the p -adic valuations of the roots of this polynomial can be studied using its Newton polygon $\text{NP}(f)$.

Also associated to f is a convex n -dimensional polytope Δ . The Hodge polygon of Δ is a combinatorial object which is a lower bound for $\text{NP}(f)$. In this paper, we apply Wan's simplicial decomposition theory to determine the Newton polygons for several families of Laurent polynomials f under certain congruence conditions. Specifically, we study non-diagonal reflection and Kloosterman variants of a type of diagonal polynomial.

This project was initiated at the workshop WIN Women in Numbers in November 2011. (Received September 16, 2012)

- 1086-11-923 **Enrique Treviño*** (etrevin1@swarthmore.edu), 500 College Avenue, Swarthmore College, Swarthmore, PA 19081. *The Burgess inequality and the least k -th power non-residue*.

The Burgess inequality is the best upper bound we have for the character sum $S_\chi(M, N) = \sum_{M < n \leq M+N} \chi(n)$. Until recently, no explicit estimates had been given for the inequality. In 2006, Booker gave an explicit estimate for quadratic characters which he used to calculate the class number of a 32-digit discriminant. McGown used an explicit estimate to show that there are no norm-Euclidean Galois cubic fields with conductor greater than 10^{70} . Both of their explicit estimates are on restricted ranges. In this talk we give an explicit estimate that works for any integers M and N . We also improve McGown's estimates in a slightly narrower range, getting explicit estimates for characters of any order. We apply the estimates to the question of how large must a prime p be to ensure that there is a k -th power nonresidue less than $p^{1/6}$. (Received September 24, 2012)

- 1086-11-924 **Atul Dixit** and **Arindam Roy*** (roy22@illinois.edu), 1409 West green street, Urbana, IL 61801, and **Alexandru Zaharescu**. *Ramanujan-Hardy-Littlewood-Riesz Phenomena for Hecke Forms*.

We generalize a Ramanujan-Hardy-Littlewood result to primitive Hecke forms, which interestingly exhibits faster convergence than in the initial case of the Riemann zeta function. We also provide a criterion in the spirit of Riesz for the Riemann Hypothesis for the associated L -functions. (Received September 16, 2012)

- 1086-11-928 **Qingquan Wu*** (qingquan.wu@tamiu.edu), 5201 University Blvd, EMAP, TAMIU, Laredo, TX 78041. *The divisor class numbers of certain function fields*.

We investigate the Sylow p -subgroup of the divisor class groups of certain function fields of extension degree p . When $p=2$, this is Gauss' genus theory. However, when we try to generalize the research objects to singular curves, it seems that new techniques are necessary to explore this case. We strive to obtain a lower bound of the p -rank of the divisor class groups, which is about half of the size of the non-singular case.

This is a joint work with Tobias Bembom and Renate Scheidler. (Received September 16, 2012)

1086-11-936 **Behailu Mammo*** (matbzm@hofstra.edu), 168 Greengrove Ave, Uniondale, NY 11553, and **Arulappah Eswarhasan**. *On the one-third squares in the psudo-Lucas sequence.*

For each integer $n \geq 1$, psudo-Lucas numbers are defined by

$$U_1 = 1, \quad U_2 = 6, \quad U_{n+2} = U_{n+1} + U_n$$

In this talk, we will show that none of psudo-Lucas numbers is of the form $3m^2$, where m is an integer. (Received September 16, 2012)

1086-11-937 **Wei Ho*** (who@math.columbia.edu) and **Aise Johan de Jong**. *Genus one curves and Brauer-Severi varieties.*

Given a Brauer-Severi variety X over a field, is there always a genus one curve that maps to X ? We explicitly construct such a curve for the cases where X has dimension at most 4. (Received September 16, 2012)

1086-11-943 **Andrew Shallue*** (ashallue@iwu.edu) and **Steven Hayman** (steven.paul.hayman@gmail.com). *Constructing a ten-billion factor Carmichael number.*

We have constructed a Carmichael number with 10,333,229,505 prime factors. This required developing a new subset-product algorithm that utilizes ideas of Kuperberg and exploits the non-uniform distribution of primes p with the property that $p - 1$ divides a highly composite Λ . (Received September 16, 2012)

1086-11-1010 **Dae San Kim*** (dskim@sogang.ac.kr), Department of Mathematics, Sogang University, Seoul, 121-742, South Korea, and **Taekyun Kim** (tkkim@kw.ac.kr), Department of Mathematics, Kwangwoon University, Seoul, 139-701, South Korea. *Identities involving higher-order Bernoulli and Euler polynomials.*

In this paper, we develop methods of expressing any polynomial with rational coefficients as a rational linear combination of higher-order Bernoulli polynomials and as that of higher-order Euler polynomials. As applications, we will derive some interesting arithmetic identities involving higher-order Bernoulli or higher-order Euler polynomials. Here first we consider the cases that the orders are equal and then we extend those to the cases that the orders are unequal. (Received September 17, 2012)

1086-11-1014 **Elena Fuchs*** (efuchs@math.berkeley.edu). *Arithmetic of thin groups.*

In the last few years there has been an increase in interest in arithmetic problems connected to so-called thin groups, mainly because tools to tackle such problems have only recently been developed. In this talk, we explore a few such arithmetic problems and discuss some of the questions that remain to be answered in the area. (Received September 17, 2012)

1086-11-1019 **Marie-Jose Bertin, Amy Feaver, Jenny Fuselier, Matilde Lalin and Michelle Manes*** (mmanes@math.hawaii.edu), UH Department of Mathematics, 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822. *Mahler measure of some singular $K3$ -surfaces.*

Jensen's formula relates the Mahler measure of a one-variable polynomial to a simple formula depending on the roots of the polynomial. The situation for multivariate polynomials is quite different. Beginning in the 1970s and continuing to the present day, researchers have explored the connection between the Mahler measure of a polynomial defining an elliptic curve and the L -function of that curve. A natural extension of this line of inquiry involves connecting the polynomials whose zeros define Calabi-Yau varieties of dimension greater than one with L -functions associated to those varieties. In two dimensions, that means connecting the Mahler measure of polynomials to the L -functions of elliptic $K3$ -surfaces.

Building on previous work of Bertin, we prove three new formulas of this type. The strategy for proving these formulas is as follows:

- Understand the transcendental lattice and the group of sections for the $K3$ -surface.
- Relate the Mahler measure of the polynomial to the L -function of a modular form.
- Relate the L -function of the $K3$ -surface to the L -function of that same modular form.

We will outline each piece of the argument and point out technical difficulties that arise in some cases. (Received September 18, 2012)

1086-11-1039 **Luis Finotti*** (finotti@math.utk.edu), 1403 Circle Drive, Dept. of Mathematics, University of Tennessee, Knoxville, TN 37996. *Liftings of Elliptic and Hyperelliptic Curves.*

We will discuss computations with canonical liftings of elliptic curves, including the problem of lifting j -invariants, and relations with minimal degree liftings of hyperelliptic curves. (Received September 18, 2012)

- 1086-11-1085 **Andrew G. Earnest*** (aearnest@siu.edu), Department of Mathematics, Southern Illinois University Carbondale, Carbondale, IL 62901. *Strictly Regular Positive Definite Quaternary Quadratic Forms and Lattices.*

A positive definite quadratic \mathbb{Z} -lattice is said to be *strictly regular* if it primitively represents all positive integers that are primitively represented by its genus. It will be shown that there exist only finitely many isometry classes of primitive integral positive definite quaternary quadratic \mathbb{Z} -lattices that are strictly regular. The complete enumeration of the diagonalizable lattices having this property will be described. As a consequence, all one-class genera of diagonal quaternary quadratic forms are determined. The work described in this talk is joint work with Ji Young Kim of Seoul National University. (Received September 18, 2012)

- 1086-11-1089 **Xinyun Zhu*** (zhu_x@utpb.edu), Department of Mathematics and Computer Sci, 4901 E University Blvd, University of Texas at Permian Basin, Odessa, TX 79762, **Aklilu Zeleke** (zeleke@msu.edu), Department of Statistics and Probability, A440 Wells Hall, Michigan State University, East Lansing, MI 48824, **Sivaram Narayan** (sivaram.narayan@cmich.edu), Department of Mathematics, Pearce Hall 218, Central Michigan University, Mount Pleasant, MI 48859, and **George Grossman** (grosslgw@cmich.edu), Department of Mathematics, Pearce Hall 217, Central Michigan University, Mount Pleasant, MI. *Recursive relations and combinatorial identities.*

In this paper we generate solutions of a real, doubly indexed, second order recurrence relation of the form

$$-a_{k,n} - ba_{k,n+1} + ca_{k,n+2} = \binom{n+k+2}{n+2} \quad (1)$$

with initial conditions, by two approaches, where b, c are real numbers, $c \neq 0$ and $\binom{n+k+2}{n+2}$ is binomial coefficient. We give the generating function for $a_{k,n}$, $n, k \geq 0$. We also express term $a_{k,n}$ explicitly, as a finite, double sum, with binomial coefficients and terms of the form b^p/c^q , for some positive integers p, q . Equating two equivalent solutions, we note that an interesting sequence of combinatorial identities can be determined and give some examples. (Received September 18, 2012)

- 1086-11-1098 **Steven J Miller*** (sjm1@williams.edu), Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267, and **Amanda Bower, Rachel Insoft, Shiyu Li and Philip Tosteson.** *Distribution of summands in generalized Zeckendorf decompositions.*

A beautiful theorem of Zeckendorf states that every positive integer can be written uniquely as a sum of non-consecutive Fibonacci numbers. Once this has been shown, it's natural to ask how many Fibonacci numbers are needed. Using continued fractions, Lekkerkerker proved that the average number of such summands needed for integers in $[F_n, F_{n+1})$ is $n/(\phi^2 + 1)$, where ϕ is the golden mean. We present a combinatorial proof of this through the cookie problem and differentiating identities, and further prove that the fluctuations about the mean are normally distributed and the distribution of gaps between summands is exponentially decreasing. These techniques apply to numerous generalizations (many involving representations arising from continued fractions), which we'll discuss as time permits. (Received September 18, 2012)

- 1086-11-1103 **Jacqueline Anderson, Jennifer S. Balakrishnan*** (jen@math.harvard.edu), **Kristin Lauter, Jennifer Park and Bianca Viray.** *Comparing the arithmetic intersection formulas of Bruinier-Yang and Lauter-Viray.*

Bruinier and Yang gave a conjectural formula for the arithmetic intersection number $CM(K).G_1$ on the Siegel moduli space of abelian surfaces. This intersection number allows one to compute the denominators of Igusa class polynomials and has applications to the construction of genus 2 curves for use in cryptography.

Yang proved this conjecture under certain assumptions on the ramification in the quartic CM field K . More recently, Lauter and Viray gave a seemingly different formula for this intersection for a larger class of primitive quartic CM fields. We discuss each formula and sketch the correspondence between the two formulas in the range where they both apply. (Received September 18, 2012)

- 1086-11-1123 **Claudia A Spiro*** (cspiro@spsu.edu), Southern Polytechnic State University, Mathematics Department, 1100 S. Marietta Parkway, Marietta, GA 30060. *A property of the Number 2013, preliminary Report.* Preliminary report.

The number 2013 has the property that if its prime divisors are arranged in ascending order, and p and q are two of them with $p|q$, then $p-1$ divides $q-1$. We show that if $N(x)$ is the number of positive integers not exceeding x that have this property, then we have

$$N(x) \sim cx/\log x$$

for a positive computable constant c , where $\log x$ is the natural logarithm of x . We apply the argument to more general settings involving the Euler ϕ -function, the group-counting function, and other problems about chains of primes in arithmetic progressions. (Received September 19, 2012)

1086-11-1172 **Dong Quan Ngoc Nguyen*** (dongquan@math.ubc.ca), Department of Mathematics, University of British Columbia, 1984 Mathematics Road, Vancouver, BC V6T 1Z2, Canada. *Generalized Mordell curves, generalized Fermat curves, and the Hasse principle.*

We show that for each prime $p \equiv 1 \pmod{8}$, there exists a threefold X_p such that the existence of certain rational points on X_p produces families of generalized Mordell curves and families of generalized Fermat curves violating the Hasse principle explained by the Brauer-Manin obstruction. We also introduce a notion of the descending chain condition for sequences of curves, and prove that there are sequences of generalized Mordell curves and generalized Fermat curves satisfying the descending chain condition. (Received September 19, 2012)

1086-11-1174 **Jennifer S. Balakrishnan*** (jen@math.harvard.edu), **Mirela Ciperiani** and **William A. Stein**. *p -adic heights of Heegner points and Heegner L -functions.*

Let E be an elliptic curve defined over the rationals. In 2006, Mazur, Stein, and Tate gave an algorithm to compute p -adic heights on E . We describe a few algorithms to compute p -adic heights of points of E defined over number fields. Applying these methods to Heegner points of non-fundamental discriminant, we discuss the computation of the first explicit examples of Heegner L -functions and anticyclotomic Λ -adic regulators. (Received September 19, 2012)

1086-11-1183 **Mirela Ciperiani***, The University of Texas at Austin, Austin, TX 78712. *The computation of anticyclotomic Λ -adic regulators of elliptic curves.*

Let E be an elliptic curve defined over \mathbb{Q} , K an imaginary quadratic field, and p a prime of good ordinary non-anomalous reduction. Set \mathcal{U} to be the inverse limit of the points of E defined over the layers of the anticyclotomic \mathbb{Z}_p -extension of K . The image of \mathcal{U} under the cyclotomic p -adic height pairing is generated by the anticyclotomic Λ -adic regulator. If K satisfies the Heegner hypothesis, the elliptic curve has analytic rank 1 over K , and the Heegner point defined over K is not divisible by p , then Heegner points generate \mathcal{U} .

In this talk, we will describe a method that allows us to compute anticyclotomic Λ -adic regulators. We generalize results of Cohen and Watkins, and thereby compute Heegner points defined over different layers of the anticyclotomic \mathbb{Z}_p -extension of K . We also prove a connection which gives rise to an efficient way of using results of Mazur-Stein-Tate to compute p -adic heights. This is joint work with Jennifer Balakrishnan and William Stein. (Received September 19, 2012)

1086-11-1202 **J. Brian Conrey*** (conrey@aimath.org), 360 Portage Ave, Palo Alto, CA 94306. *Zeros of period polynomials.*

We show that apart from 5 “trivial” zeros, all of the zeros of the period polynomial associated with a newform of level one are on the unit circle. This work is joint with David Farmer and Ozlem Imamoglu (Received September 20, 2012)

1086-11-1224 **Wei Ho*** (who@math.columbia.edu). *How many rational points does a random curve have?* Although algebraic curves are very well-studied objects in modern number theory and algebraic geometry, there remain many open questions about some of their most basic properties! In this talk, I will discuss the idea of rational points on a curve and indicate why this concept is particularly fascinating and rewarding for a certain class of curves called elliptic curves.

One of the most beautiful and useful features of an elliptic curve is that its set of rational points forms a finitely generated abelian group. How often is this group finite? If it is infinite, what is its rank?

The “minimalist conjecture,” originating in work of Goldfeld from 1979, suggests that a “random” elliptic curve has a 50% chance of having only finitely many rational points. I will give an overview of recent results in this direction, led by the work of Bhargava and Shankar bounding the “average” rank of an elliptic curve. (Received September 20, 2012)

1086-11-1225 **Wei Ho*** (who@math.columbia.edu). *Applications of Explicit Moduli Spaces and Geometry of Numbers.* Preliminary report.

One method of proving statistics related to arithmetic objects has been to first explicitly parametrize the objects, and then apply geometry-of-numbers techniques to the integral points in the moduli spaces in order to count them. We discuss some new applications of this technique. (Received September 20, 2012)

- 1086-11-1234 **John Voight*** (jvoight@gmail.com), Department of Mathematics, University of Vermont, 16 Colchester Ave, Burlington, VT 05401. *Discriminants and the monoid of quadratic rings.*

We consider the natural monoid structure on the set of quadratic rings over an arbitrary base scheme and characterize this monoid in terms of discriminants. (Received September 20, 2012)

- 1086-11-1259 **Jennifer S. Balakrishnan*** (jen@math.harvard.edu), **J. Steffen Müller** and **William A. Stein**. *A p -adic Birch and Swinnerton-Dyer conjecture for modular abelian varieties.*

In 1986, Mazur, Tate, and Teitelbaum gave a p -adic analogue of the conjecture of Birch and Swinnerton-Dyer for elliptic curves over the rationals. We discuss a generalization of this conjecture to the case of modular abelian varieties and primes p of good ordinary reduction.

We will briefly outline algorithms to compute the appropriate p -adic L -series and p -adic regulators and discuss numerical evidence for the conjecture in the case of modular abelian surfaces. (Received September 20, 2012)

- 1086-11-1302 **Song Heng Chan** (chansh@ntu.edu.sg), School of Physical & Mathematical Sciences, Nanyang Technological University, 21 Nanyang link, Singapore, 637371, Singapore, 637371, Singapore, **Atul Abhay Dixit*** (adixit@tulane.edu), Department of Mathematics, Tulane University, 6823 Saint Charles Avenue, New Orleans, LA 70118, and **Frank G. Garvan** (fgarvan@ufl.edu), Department of Mathematics, University of Florida, Gainesville, Gainesville, FL 32611. *Rank-Crank-type PDEs and generalized Lambert series identities.*

We show how Rank-Crank type PDEs for higher order Appell functions due to Zwegers may be obtained from a generalized Lambert series identity due to Chan. Special cases are the Rank-Crank PDE due to Atkin and Garvan and a PDE for a level 5 Appell function found by Garvan. These two special PDEs are related to generalized Lambert series identities due to Watson and Jackson respectively. Chan's Lambert series identity is a common generalization. We also show how Atkin and Swinnerton-Dyer's proof using elliptic functions can be extended to prove this generalized Lambert series identity. This is joint work with Song Heng Chan and Frank G. Garvan. (Received September 20, 2012)

- 1086-11-1342 **David H Bailey*** (dhbailey@lbl.gov), Mail Stop 50F-1650, Berkeley, CA 94720. *Computational Discovery of Number Theory Identities for Mathematical Physics Integrals.*

A frequent theme of 21st century "experimental mathematics" is the computer-based discovery of identities for mathematical entities arising in mathematical physics. This is typically done by means of computing some mathematical entity (a sum, integral, limit, etc.) to very high numeric precision, then using the PSLQ algorithm to identify the entity as a relatively simple expression involving well known constants.

Perhaps the most successful application of this methodology has been to identify integrals and summations arising in mathematical physics. This talk will present several examples of this type, including integrals from quantum field theory, Ising theory, random walk theory, 3D lattice problems, and Mordell-Tornheim-Witten zeta functions. Computing these integrals or sums to very high precision (typically several hundred digits) is itself a daunting technical challenge, requiring advanced techniques. In some cases, it is necessary to compute these entities to over 3000-digit precision. Rigorously proving the discovered identities is a separate challenge, requiring distinct methods. (Received September 21, 2012)

- 1086-11-1347 **Lance Edward Miller*** (lmiller@math.utah.edu) and **Benjamin Steinhurst**. *Witt-Burnside rings and rings of p -adic functions.* Preliminary report.

In this talk, we explore an interpretation of Witt-Burnside rings with rings of p -adic continuous functions. In particular, we demonstrate a homomorphism from $W_{Z_p^2}(k)$ to the continuous $W(k)$ -valued functions on $P^1(Q_p)$. We exploit this to get a better understanding of the ring structure of $W_{Z_p^2}(k)$. (Received September 21, 2012)

- 1086-11-1348 **William Duke*** (wdduke@ucla.edu). *The Fourier coefficients of harmonic Maass forms of weight one.*

In this talk I will report on joint work with Yingkun Li on some arithmetic properties of the Fourier coefficients of harmonic modular forms of weight one. These are Maass forms of weight one whose eigenvalue under the Laplacian is 0 and that are allowed to have polar-type singularities in the cusps. We show that in some cases they are connected to the Galois representations associated to newforms of weight one. (Received September 24, 2012)

1086-11-1355 **Dermot McCarthy*** (mccarthy@math.tamu.edu). *The trace of Frobenius of elliptic curves and the p -adic gamma function.*

In this talk we will introduce a new function which is defined in terms of quotients of the p -adic gamma function. This function extends hypergeometric functions over finite fields to the p -adic setting. We will outline recent work in which we prove that, for primes $p > 3$, the trace of Frobenius of any elliptic curve over \mathbb{F}_p , whose j -invariant does not equal 0 or 1728, is just a special value of this function. This generalizes results of Fuselier and Lennon which evaluate the trace of Frobenius in terms of hypergeometric functions over \mathbb{F}_p when $p \equiv 1 \pmod{12}$. (Received September 21, 2012)

1086-11-1366 **Ognian Trifonov*** (trifonov@math.sc.edu), Department of Mathematics, LeConte College, 1523 Greene Street, University of South Carolina, Columbia, SC 29208. *Bounds on the largest modulus of a covering with a fixed smallest modulus.* Preliminary report.

Suppose $n > 1$ is an integer. Define $k(n)$ as the least rational number such that there exists a covering with distinct moduli, all in the interval $[n, n \cdot k(n)]$. If no such covering exists, define $k(n) = \infty$. Recently, Filaseta, Ford, Konyagin, Pomerance, and Yu showed that $k(n) \rightarrow \infty$ as $n \rightarrow \infty$. Krukenberg showed $k(2) = 6$ and $k(3) = 12$. We prove that $k(4) = 15$, get bounds for $k(5)$, and show that $k(n) > 6$ for all integers $n > 2$. (Received September 21, 2012)

1086-11-1383 **James Brandt Kronholm*** (kronholm@juniata.edu), 1700 Moore Street, Huntingdon, PA 16652. *Towards a Complete Characterization of Prime Divisibility Properties of the Restricted Partition Function $p(n, m)$.*

In this presentation we will discuss an intriguing extension of a previous result regarding divisibility properties of $p(n, m)$, the restricted partition function that enumerates the number of partitions of n into exactly m parts. This extension reveals further symmetries of the generating functions and may allow us to gain a better understanding of the associated Ramanujan-like congruences, some of which defy generalization so far. Moreover, this extension agrees with the Hardy-Ramanujan-Rademacher formula for $p(n)$ when n is negative, namely, $p(n) = 0$. (Received September 21, 2012)

1086-11-1398 **Lenny Fukshansky and Glenn Henshaw*** (glenn.henshaw@csuci.edu). *Height bounds over quaternion algebras.*

Siegel's Lemma, which concerns the existence of points of small height in a linear space, and Cassels' theorem, concerning the existence of points of small height in a quadratic space, have been generalized by various authors in recent years. In this talk we will discuss certain noncommutative analogues of these types of results with additional algebraic conditions. Specifically, let D be a positive definite quaternion algebra over a totally real number field K . We will describe a general principle that allows one to obtain effective existence results with respect to height over D by transferring analogous results over K . In particular we will discuss noncommutative analogues of recent results of the authors with W. K. Chan and give estimates for the number of points of bounded height over an arbitrary order of D . (Received September 21, 2012)

1086-11-1426 **Krishna Dasaratha, Laure Flapan, Thomas Garrity*** (tgarrity@williams.edu), **Chansoo Lee, Cornelia Mihaila, Nicholas Neumann-Chu, Sarah Peluse and Matthew Stroffregen.** *Cubic Irrationals and Periodicity via a Family of Multi-dimensional Continued Fraction Algorithms.*

It has long been unknown if there is an algorithm to represent any real number by a sequence of integers such that the sequence is eventually periodic if and only if the real number is a cubic irrational. This is the Hermit problem. We construct a countable family of multi-dimensional continued fraction algorithms, built out of five specific multidimensional continued fractions, and show that a real number is a cubic irrational precisely when its multidimensional continued fraction expansion with respect to at least one element of the countable family is eventually periodic. We interpret this result as the construction of a matrix with entries of non-negative integers such that at least one of the rows is eventually periodic if and only if the initial real is a cubic irrational. (Received September 21, 2012)

1086-11-1436 **Joseph H Silverman***, Mathematics Department, Box 1917, Brown University, Providence, RI 02912. *Dynamical Degree and Arithmetic Entropy for Rational Maps.* Preliminary report.

Let $f : X \dashrightarrow X$ be a dominant rational self-map of a smooth projective variety defined over $\overline{\mathbb{Q}}$. The dynamical degree δ_f of f is a real number that measures the dynamical complexity of the iterates f^n of f . I will describe how δ_f also bounds the arithmetic complexity of the f -orbit of a point $P \in X(\overline{\mathbb{Q}})$. More precisely, for every $\varepsilon > 0$ and ample height function h_X , we have $h_X(f^n(P)) \leq C_{f,\varepsilon}(\delta_f + \varepsilon)^n h_X(P)$. Applications include an inequality

$\alpha_f(P) \leq \delta_f$ for the arithmetic entropy and the construction of a dynamical canonical height for morphisms f satisfying an algebraic equivalence $f^*D \equiv \beta D$ for some $\beta > \sqrt{\delta_f}$. (Joint work with Shu Kawaguchi.) (Received September 21, 2012)

1086-11-1450 **Alexandru Buium*** (buium@math.unm.edu). *Differential lifts and differential symmetries*. Preliminary report.

Various classes of phenomena in algebraic geometry in characteristic p do not lift to algebraic geometry in characteristic zero. (Examples of such phenomena arise, for instance, in relation to modular forms or in relation to Galois theory.) However it turns out that some of these phenomena in characteristic p admit remarkable lifts to characteristic zero in “delta-geometry” (the geometry of “arithmetic differential equations”). These “differential lifts” possess certain unexpected “differential symmetries” and can be viewed as central fibers of “differential deformations”. This may arguably make delta-geometry (rather than algebraic geometry) the “correct deformation theory” for many arithmetical problems. A conjectural framework and results will be presented supporting the above phenomenology. (Received September 22, 2012)

1086-11-1456 **Jodi Black*** (jodi.black@bucknell.edu), 380 Olin Science Building, Bucknell University, Lewisburg, PA 17837, and **R. Parimala** (parimala@mathcs.emory.edu). *Zero cycles on torsors under groups of low rank*.

Let k be a field and let G be a connected linear algebraic group over k . In a 2004 paper, Totaro asked whether a torsor under G and over k , which admits a zero cycle of degree d , also admits a closed étale point of degree dividing d . We give a positive answer to this question for some semisimple groups of low rank when k is perfect and of characteristic different from 2. (Received September 22, 2012)

1086-11-1458 **Barry C Mazur*** (mazur@math.harvard.edu). *Arithmetic statistics of central zeroes of L -functions of the symmetric n -th powers of a given automorphic form*.

Given an elliptic curve over the rational numbers, and letting p range through prime numbers, how often is $p+1$ an over-count or an under-count for the number of rational points on the curve modulo p ? The rough answer is 50/50, but for finer statistics it is useful to know about the “zeroes” alluded to in the title. Here, computation can even outstrip theory in that people have algorithms to make such computations whether or not the holomorphicity of the L -functions in question have been proved. I have no new results here, but my aim in twenty minutes, is to advertise some conjectures (and some recent work) regarding this problem that suggest interesting computational projects. (Received September 22, 2012)

1086-11-1475 **Jeffrey C Lagarias*** (lagarias@umich.edu) and **David Montague** (davmont@math.stanford.edu). *Correlations of Fractional Parts of Dilated Harmonic Sequences*.

The harmonic sequence is $y_k = 1/k$, and for positive integer n let $x_k = \{n/k\}$ be the fractional parts of the dilated harmonic sequence n/k . We consider the distribution of the fractional parts of the initial part of the sequence x_k from 1 to $f(n)$, where we will let $f(n) \rightarrow \infty$ as $n \rightarrow \infty$. For example, taking $f(n) = n$ it is known that the average value of the fractional parts is $1 - \gamma = 0.42278\dots$, where γ is Euler’s constant, a result of de la Vallée Poussin. We study statistics attached to such distributions, including all the r -point distributions of $(x_k, x_{k+1}, \dots, x_{k+r})$. We determine sufficient conditions on $f(n)$ to get a limiting distribution, and determine information about this distribution given in terms of its Fourier coefficients, which depend on the function $f(n)$. (Received September 22, 2012)

1086-11-1482 **George J. Schaeffer*** (gschaeff@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *The Hecke stability method*.

The Galois representations associated to spaces of weight 1 cusp forms mod p have several interesting arithmetic properties (for example, their projectivizations are unramified at p). However, such spaces cannot be computed “directly” using modular symbols. In this talk I will outline the “Hecke stability method” which, for a given N , computes the space of weight 1 level N cusp forms modulo all primes p simultaneously. Time permitting, I will also present some remarkable data which this method has produced. (Received September 22, 2012)

1086-11-1497 **Mark Kozek*** (mkozek@whittier.edu), Department of Mathematics, Whittier College, Whittier, CA 90608-0834. *Recent undergraduate research on coverings*. Preliminary report.

We describe recent undergraduate research projects on coverings and their results (from the 2012 Cornell Summer Math Institute).

- For each base $2 \leq b \leq 9$, we show there are infinitely many composite numbers (coprime to b) that remain composite after changing any digit in their base- b expansion. For $2 \leq b \leq 5$ we study an analogous problem for changing any two adjacent digits.
- An IRDCS is an incongruent restricted disjoint covering system, that is, an incongruent disjoint covering system on restricted interval. We study the general structure of IRDCSs, and we present some results on the 9-6-3 family of IRDCSs.
- Erdos' minimum modulus problem asks, given any natural number c , can one construct a covering system using distinct moduli greater than or equal to c ? We explore various ways to 'minimize' such coverings.

(Received September 25, 2012)

1086-11-1516 **Arnab Saha*** (arnab.saha@anu.edu.au), John Dedman Building, No-27, Australian National University, Canberra, ACT 0200, Australia. *Differential Modular forms and Hecke Operators.*

Arithmetic jet spaces enlarge the regular algebraic geometry by considering "differential equations" that are satisfied by numbers with respect to a p -derivation δ . Differential modular forms are obtained from the usual modular forms by considering the arithmetic jet spaces on it. We will study the action of the Hecke operators on these differential modular forms. (Received September 23, 2012)

1086-11-1518 **Frank Garvan** and **Jie L Liang*** (jieliang@ufl.edu). *Automatic Proof of Theta-Function Identities.* Preliminary report.

We present a MAPLE package that utilizes the valence formula for proving theta-function identities for generalized eta-products. By rewriting a supposed theta-function identity as a sum of generalized eta-products, we use MAPLE to: (1) check that each term in the sum is indeed a generalized eta-product on $\Gamma_1(N)$ using a result of Robins; (2) find a set of inequivalent cusps for $\Gamma_1(N)$ and the fan width of each cusp; (3) calculate the invariant order of each generalized eta-product in the sum at each cusp of $\Gamma_1(N)$; and (4) apply the valence formula to determine a lower bound for the number of terms to check in the q -expansion of the identity. We prove some new identities. (Received September 24, 2012)

1086-11-1539 **Gautam Chinta***, CCNY, Dept. of Mathematics, NAC 8-133, New York, NY 10031. *Prehomogeneous vector spaces and number theory.*

We will describe some examples of prehomogeneous vector spaces which parametrize objects of number theoretic interest and discuss the associated zeta functions. (Received September 23, 2012)

1086-11-1548 **Sarah A Chisholm*** (chisholm@math.ucalgary.ca), 841-B Northmount Drive NW, Calgary, Alberta T2L 0A3, Canada. *Quaternionic lattice neighbours and automorphic forms.* Preliminary report.

In this talk, I will describe a method for computing automorphic forms for definite quaternionic unitary groups, objects of significant interest owing to their role in the Langlands program and their conjectural connection to Galois representations. Our main computational tool is the theory of quaternionic lattice neighbours, developed by Bachoc following ideas of Kneser. (Received September 23, 2012)

1086-11-1572 **Sean Howe*** (seanpkh@gmail.com). *Presentations of S -unit groups of quaternion algebras ramified at infinity and applications to the congruence subgroup problem.* Preliminary report.

For k a number field and \mathcal{B}/k a quaternion algebra totally ramified at infinity, and for S a sufficiently large set of places of k , we give an algorithm to determine a presentation of the S -units of \mathcal{B} modulo scalars. The algorithm calculates a presentation based on a fundamental domain for the action of the S -units on a product of Bruhat-Tits trees given by Chinburg and Stover ([arXiv:1204.5968](https://arxiv.org/abs/1204.5968)) in their work on finding generators for S -units of division algebras, combined with either Bass-Serre theory or a theorem of MacBeath on presentations of groups acting on simply connected topological spaces. In the case of the Hamiltonian quaternions over \mathbb{Q} , the resulting presentations take a particularly nice form, with potential applications to the congruence subgroup problem for the corresponding algebraic groups. For example, we show that for p an odd prime such that $p \equiv 2 \pmod{3}$, the $\{p, \infty\}$ -units of the Hamiltonian quaternions admit a surjective morphism to $PSL_2(\mathbb{Z})$. This talk is based on work begun at the 2012 Arizona Winter School and is joint work with the other members of Chinburg and Stover's Arizona Winter School project group. (Received September 23, 2012)

- 1086-11-1593 **Brooke Feigon***, Department of Mathematics, The City College of New York (CUNY), NAC 8/133, New York, NY 10031. *L-functions, periods and the relative trace formula for $GL(2n)$.*

An important result of Waldspurger relates central values of quadratic base change L-functions of cusp forms on $GL(2)$ to period integrals over the corresponding tori. This result was reproved by Jacquet using the relative trace formula. In this talk I will discuss joint work with Kimball Martin and David Whitehouse on extending Jacquet's approach to Waldspurger's result to higher rank groups. (Received September 23, 2012)

- 1086-11-1619 **Tim Huber*** (hubertj@utpa.edu) and **James Lloyd** (jelloyd@broncs.utpa.edu). *Elliptic parameterizations for partition generating functions.*

We show that Ramanujan's congruences for the partition function may be formulated and extended by employing classical product expansions for the Weierstrass elliptic functions. These identities motivate factorizations for more general partition generating functions, such as those for t -cores, in terms of certain weight one modular forms. (Received September 24, 2012)

- 1086-11-1622 **Amir Akbary*** (amir.akbary@uleth.ca), Department of Mathematics and CS, University of Lethbridge, Lethbridge, Alberta T1K 3M4, Canada. *Periods of orbits modulo primes.*

We review some classical results on the lower bounds (in terms of p) for the order of an integer modulo primes p and describe their generalizations in the context of reduction mod p of points on elliptic curves. We also give a dynamical interpretation of such results, more precisely, for an endomorphism φ of a variety V defined over \mathbb{Q} we prove a lower bound for the size of the reduction modulo primes of the φ -orbit of any point $\alpha \in V(\mathbb{Q})$. Some of the results are joint work with Dragos Ghioca and Kumar Murty. (Received September 23, 2012)

- 1086-11-1627 **David Leep*** (leep@email.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506-0027. *The represented values of a positive definite quaternary quadratic form.* Preliminary report.

Let $q = ax^2 + by^2 + cz^2 + dw^2$ where a, b, c, d are positive integers. There is a vast literature on the problem of determining which integers are represented by q . The problem of determining which of these forms represents all but finitely many positive integers has been studied thoroughly. Important contributions have made by Lagrange, Liouville, Ramanujan, Dickson, Kloosterman, Ross, Pall, as well as more recent authors. This talk will survey some of these results, as well as address some other questions related to this material. (Received September 23, 2012)

- 1086-11-1634 **Paul Pollack*** (pollack@uga.edu), Boyd Graduate Studies Research Center, Mathematics Department, UGA, Athens, GA 30602. *The smallest prime with a given splitting type in an abelian number field.*

Let K/\mathbb{Q} be a finite, abelian extension. We describe a method, developed out of work of Linnik-Vinogradov and Elliott, for bounding above the smallest rational prime that is unramified and splits into a given number of distinct prime ideals in \mathcal{O}_K . One corollary is that for each $\epsilon > 0$, the smallest prime that splits completely in K is $O_{n,\epsilon}(|D|^{\frac{1}{4}+\epsilon})$, where n denotes the degree of K/\mathbb{Q} and D denotes its discriminant. We also give some applications to computing average prime-splitting statistics for families of number fields. (Received September 23, 2012)

- 1086-11-1643 **Karl Dilcher*** (dilcher@mathstat.dal.ca), Department of Mathematics & Statistics, Dalhousie University, Halifax, NS B3H 4R2, Canada, and **Kenneth B. Stolarsky**. *Stern polynomials and continued fractions.*

We derive identities for a polynomial analogue of the Stern sequence and define two subsequences of these polynomials. We obtain various properties for these two interrelated subsequences which have 0-1 coefficients and can be seen as extensions or analogues of the Fibonacci numbers. We also define two analytic functions as limits of these sequences. As an application we obtain evaluations of certain finite and infinite continued fractions whose partial quotients are doubly exponential. In a case of particular interest, the set of convergents has exactly two limit points. (Received September 23, 2012)

- 1086-11-1658 **Daniel J Kriz***, 1 Nassau Hall, Princeton, NJ 08544. *On the Maximal Cross Number of Unique Factorization Multisets.*

We study a conjecture of Gao and Wang concerning a proposed formula $K_1^*(G)$ for the maximal cross number $K_1(G)$ occurring among all unique factorization multisets over a given finite abelian group G . As a corollary of our first main result, we verify the conjecture for groups of the form $C_{p^m} \oplus C_p, C_{p^m} \oplus C_q, C_{p^m} \oplus C_q^2, C_{p^m} \oplus C_r^m$ where p, q are distinct primes and $r \in \{2, 3\}$. In our second main result we verify that $K_1(G) = K_1^*(G)$ for

groups of the form $C_r \oplus C_{p^m} \oplus C_p, C_{rp^m q}$ and $C_r \oplus C_p \oplus C_q^2$ for $r \in \{2, 3\}$ given some restrictions on p and q . We also study general techniques for computing and bounding $K_1(G)$, and derive an asymptotic result which shows that $K_1(G)$ becomes arbitrarily close to $K_1^*(G)$ as the smallest prime dividing $|G|$ goes to infinity, given certain conditions on the structure of G . We give new bounds for the cases when G is an arbitrary abelian p -group, in particular showing that in the case of p -groups, $K_1(G)$ is within $O\left(\frac{\log p}{p}\right)$ of $K_1^*(G)$ for all sufficiently large p , and also derive some necessary properties of the structure of unique factorization multisets which would hypothetically violate $k(S) \leq K_1^*(G)$. (Received September 23, 2012)

1086-11-1664 **Jeffrey D Achter*** (achter@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523-1874, and **Clifton Cunningham**. *L-packets and abelian varieties*. Preliminary report.

Let E/\mathbb{Q} be an elliptic curve without complex multiplication. A famous theorem of Elkies states that E has infinitely many primes of supersingular reduction; it turns out that this is equivalent to the infinitude of a certain L -packet of automorphic representations of SL_2 . I will explain this equivalence, and discuss the analogue for abelian varieties of higher dimension. (Received September 23, 2012)

1086-11-1667 **Ekin Ozman, Rachel Pries*** (pries@math.colostate.edu) and **Colin Weir**. *The p -rank of Jacobians of cyclic covers of the projective line*. Preliminary report.

The distinction between ordinary and supersingular elliptic curves can be generalized to (Jacobians of) curves of higher genus. If C is a curve defined over \mathbb{F}_p , its p -rank f measures the number of p -torsion points on its Jacobian or, equivalently, the length of the slope 0 segment of the Newton polygon of its L -function. For all $g \geq 3$ and all p and all $0 \leq f \leq g$, Faber and Van der Geer proved that there exists a smooth curve of genus g over \mathbb{F}_p with p -rank f . A similar result for hyperelliptic curves was proven by Glass and Pries. In this talk, we discuss a new result about p -ranks of curves which are a cyclic cover of the projective line. The proof uses the method of degeneration to the boundary of a Hurwitz space. (Received September 24, 2012)

1086-11-1700 **James M Borger*** (james.borger@anu.edu.au), Mathematical Sciences Institute, building 27, Australian National University, Canberra, ACT 0200, Australia. *Witt vectors and lambda-structures in arithmetic algebraic geometry*. Preliminary report.

I'll report on some recent work on Witt vectors and lambda-rings (in the sense of Grothendieck) in arithmetic algebraic geometry. (Received September 24, 2012)

1086-11-1703 **James M Borger*** (james.borger@anu.edu.au), Mathematical Sciences Institute, Building 27, Australian National University, Canberra, ACT 0200, Australia. *Witt vectors, lambda-rings, and absolute algebraic geometry*.

The analogy between number fields and function fields over finite fields has led to many advances in both subjects. Highlights include results in class field theory, on the zeros of zeta-functions, and on automorphic forms. But there is one basic way in which the two subjects differ: function fields have subfields of "constants", but number fields don't. This has been a barrier to fully importing ideas from the theory of function fields to that of number fields. In this talk, I'll explain how Witt vectors and lambda-rings, two somewhat exotic concepts in algebra, can be used to get around this barrier to some extent. (Received September 24, 2012)

1086-11-1707 **Byungchan Kim*** (bkim4@seoultech.ac.kr), School of Liberal Arts, SeoulTech, 172 Gongreung2dong, Nowongu, Seoul, 139-743, South Korea. *Identities involving partial theta functions*.

A partial theta function is a sum of the form

$$\sum_{n=0}^{\infty} (-1)^n q^{n(n-1)/2} x^n.$$

We can find many identities involving partial theta functions in Ramanujan's lost notebook [?]. Typically, Ramanujan did not record any proof or motivation for his study of partial theta functions. Thus, we do not know what led Ramanujan to study partial theta functions. However, combinatorially, identities containing partial theta function could be very interesting. In this talk, I will describe combinatorial interpretations and asymptotic behaviors of certain q -series involving partial theta functions. (Received September 24, 2012)

1086-11-1762 **Dominic Lanphier*** (dominic.lanphier@wku.edu), Mathematics Department, 1906 College Heights Blvd, Western Kentucky University, Bowling Green, KY 42101. *Arithmeticality of Rankin-Selberg kernels*.

Special values of the Rankin-Selberg convolution L -functions of two different weight cusp forms are well-known. These expressions lead to a nice closed form for the harmonic average of such values, where the average is taken

over a basis of the space of cusp forms containing the higher-weight cusp form. We interpret the harmonic average as a linear operator between spaces of cusp forms and obtain a closed expression for the harmonic average of the values over lower-weight cusp forms. As a consequence we obtain new values for certain Dirichlet series. (Received September 24, 2012)

1086-11-1776 **F. G. Garvan*** (fgarvan@ufl.edu), Department of Mathematics, University of Florida, PO BOX 118105, Gainesville, FL 32611-8105. *The smallest parts partition function.*

Let $\text{spt}(n)$ denote the number of smallest parts in the partitions of n . In 2008, Andrews found surprising congruences for the spt -function mod 5, 7 and 13. We discuss recent work on analytic, arithmetic and combinatorial properties of the spt -function. Some of this work is joint with George Andrews (PSU) and Jie Liang (UCF, UF). (Received September 24, 2012)

1086-11-1778 **Christopher R Shill*** (cshill@elon.edu) and **Chad Awtrey** (cawtre@elon.edu). *Galois 2-adic Fields of Degree 12.*

An important problem in computational number theory is to classify all finite extensions of the p -adic numbers by computing important invariants which define each extension. Current research has focused on computing Galois groups of these extensions up to degree 11. Consequently for this talk, we will focus on degree 12 extensions. We will begin with a brief overview of p -adic numbers and will conclude by discussing a method for calculating Galois groups of Galois extensions of the 2-adic numbers. (Received September 24, 2012)

1086-11-1784 **Lenny Jones** and **Maria Elena Markovich*** (mm0283@ship.edu), Shippensburg, PA 17257. *Generating Composites by Appending Digits to Certain Types of Integers.* Preliminary report.

Recently, the first author showed that, given any $d \in \{1, 3, 7, 9\}$, there exist infinitely positive integers n such that appending the digit d to the right of n any number of times always gives a composite integer. Additionally, it was shown that $n = 37$ is the smallest such integer. In this presentation we investigate these problems in the context of appending the digit d to certain types of positive integers. (Received September 24, 2012)

1086-11-1790 **David Zureick-Brown*** (dz@mathcs.emory.edu) and **David Zywina**. *Abelian varieties with big monodromy.*

Serre proved in 1972 that the image of the adelic Galois representation associated to an elliptic curve E without complex multiplication has open image; moreover, he also proved that for an elliptic curve over \mathbb{Q} the index of the image is always divisible by 2 (and in particular never surjective). More recently, Greicius in his thesis gave criteria for surjectivity and gave an explicit example of an elliptic curve E over a number field K with surjective adelic representation. Soon after, Zywina, building on earlier work of Duke, Jones, and others, proved that the adelic image ‘random’ elliptic curve is maximal.

In this talk I will explain recent joint work with David Zywina in which we generalize these theorems and prove that a random abelian variety in a family with big monodromy has maximal image of Galois. I’ll explain what big monodromy and maximal mean and explain the analytic and geometric techniques used in previous work and the new geometric ideas – in particular, Nori’s method of semistable approximation– needed to generalize to higher dimension. (Received September 24, 2012)

1086-11-1797 **David Zureick-Brown*** (dz@mathcs.emory.edu) and **Christopher Davis** (christopherjdavis@gmail.com). *Overconvergent de Rham-Witt cohomology for Algebraic Stacks.*

The de Rham-Witt complex is a complex of sheaves on the Zariski site of a scheme whose cohomology computes crystalline cohomology and whose applications abound. The analogous construction for rigid cohomology was elusive until recently – Davis, Langer, and Zink construct a complex of sheaves on the Zariski site of a scheme whose cohomology computes rigid cohomology. Olsson recently generalized both crystalline cohomology and the classical de Rham-Witt complex to stacks, with applications to log geometry and to the Cst conjecture of p -adic hodge theory.

In this talk I will explain the generalization of the overconvergent de Rham-Witt complex to stacks. (Received September 24, 2012)

1086-11-1799 **Carrie Finch, Joshua Harrington** and **Lenny Jones*** (1kjone@ship.edu), Department of Mathematics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257. *Nonlinear Sierpiński and Riesel Numbers.*

In 1960, Sierpiński proved that there exist infinitely many odd positive integers k such that $k \cdot 2^n + 1$ is composite for all positive integers n . Such values of k are known as *Sierpiński numbers*. Extending the ideas of Sierpiński

to a nonlinear situation, Chen showed that there exist infinitely many positive integers k such that $k^r \cdot 2^n + d$ is composite for all positive integers n , where $d \in \{-1, 1\}$, provided that r is a positive integer with $r \not\equiv 0, 4, 6, 8 \pmod{12}$. Filaseta, Finch and Kozek improved Chen's result by completely lifting the restrictions on r when $d = 1$, and they asked if a similar result exists if k^r is replaced by $f(k)$, where $f(x)$ is an arbitrary nonconstant polynomial in $\mathbb{Z}[x]$. In this article, we address this question when $f(x) = ax^r + bx + c \in \mathbb{Z}[x]$. In particular, we show, for various values of a, b, c, d and r , that there exist infinitely many positive integers k such that $f(k) \cdot 2^n + d$ is composite for all integers $n \geq 1$. When $d = 1$ or -1 , we refer to such values of k as *nonlinear Sierpiński* or *nonlinear Riesel* numbers, respectively. (Received September 24, 2012)

1086-11-1818 **Alexander Carl Mueller*** (amuell@umich.edu), 111 North Seventh Street Apartment 2, Ann Arbor, MI 48103. *Zeta Functions of Artin Schreier Curves via Representations of S_n .*

I will outline an approach to counting rational points on an Artin-Schreier curve X (associated to an equation of the form $y^p - y = f(x)$) involving Weil restriction of the polynomials $\text{Tr}_n(f(x))$. This construction produces an $n - 1$ dimensional variety Y_n equipped with an action of S_n . I will show how to compute the decomposition of $H^{n-1}(Y_n)$ as an S_n representation (by studying a related Fermat variety) and indicate how this information can be used to refine the Weil bound estimate for $|X(\mathbb{F}_{p^n})|$. In addition, I will explain how a similar approach can be used to compute the number of rational points modulo a certain p^v in terms of Jacobi sums. (Received September 24, 2012)

1086-11-1828 **Andreas Malmendier and Ken Ono*** (ono@mathcs.emory.edu), Dept of Math and CS, Emory University, Atlanta, GA 30322. *Ramanujan and Moonshine and topology.*

Here we shall discuss the recent appearance of Ramanujan's mock theta functions in Moonshine and topology. (Received September 24, 2012)

1086-11-1836 **Daniel Fiorilli*** (fiorilli@umich.edu), Department of Mathematics, University of Michigan, 530 Church Street, Ann Arbor, MI 48109, and **Steven J Miller** (steven.j.miller@williams.edu), Williams College, 202 Bronfman Science Center, Williamstown, MA 01267. *Surpassing the Ratios Conjecture in the 1-level density of Dirichlet L-functions.*

It is widely believed that low-lying zeros of the family of all Dirichlet L-functions modulo q are distributed like eigenvalues of large unitary matrices in the q limit. However, there are lower-order terms appearing in the 1-level density of these zeros, and these terms are not predicted by random matrix theory. One can make predictions for these lower-order terms using the ratios conjecture of Conrey, Farmer and Zirnbauer, up to an error of $q^{-1/2+\epsilon}$. We will show that when restricting the support of the test function to $(-3/2, 3/2)$ and when considering Dirichlet L-functions modulo q with $Q < q \leq 2Q$, not only can we prove the ratios conjecture's prediction, but we can actually find a new lower-order term of order $Q^{-1/2}/\log Q$. The proof relies on the fact that there are less primes congruent to 1 modulo q than to 6 modulo q , on average over q . (Received September 24, 2012)

1086-11-1871 **John J. Webb*** (webbjj@wfu.edu), Dept. of Mathematics, Wake Forest University, PO Box 7388, 127 Manchester Hall, Winston-Salem, NC 27109. *Behavior of ℓ -regular partitions modulo powers of ℓ .*

Let $\ell \geq 5$ be prime. We adapt the recent techniques developed by Folsom-Kent-Ono to study the ℓ -adic properties of the unrestricted partition function to analyze ℓ -regular partitions. In particular, we prove analogues of the famed Ramanujan Congruences for all powers of ℓ when $\ell \in \{5, 7, 11\}$. The proof utilizes connections to weakly holomorphic modular forms with bounded poles. (Received September 24, 2012)

1086-11-1903 **Andrew V. Sutherland*** (drew@math.mit.edu). *Computing the image of Galois representations attached to elliptic curves.*

Let ℓ be a prime, and let E/\mathbb{Q} be an elliptic curve. The action of the absolute Galois group $\text{Gal}(\overline{\mathbb{Q}}/\mathbb{Q})$ on the ℓ -torsion subgroup $E[\ell]$ induces a group representation $\rho_{E,\ell}: \text{Gal}(\overline{\mathbb{Q}}/\mathbb{Q}) \rightarrow \text{Aut}(E[\ell]) \simeq \text{GL}_2(\mathbb{Z}/\ell\mathbb{Z})$. A conjecture of Serre states that there is an absolute bound ℓ_{\max} such that $\rho_{\ell,E}$ is surjective for all primes $\ell > \ell_{\max}$ and all elliptic curves E/\mathbb{Q} without complex multiplication (CM); it is generally believed that the conjecture holds with $\ell_{\max} = 37$. This implies that there is a finite set of groups that arise as the image of a non-surjective representation $\rho_{\ell,E}$ for an elliptic curve E/\mathbb{Q} without CM. As a first step toward computing this set, I will describe a highly efficient algorithm for computing $\rho_{\ell,E}$ (up to isomorphism and usually up to conjugacy) for all primes ℓ up to a given bound ℓ_{\max} and all elliptic curves E in a given family. I will then present results covering all the elliptic curves without CM listed in Cremona's tables or the Stein-Watkins database. (Received September 24, 2012)

1086-11-1905 **Melvyn B. Nathanson*** (melvyn.nathanson@lehman.cuny.edu), Dept. of Mathematics, Lehman College (CUNY), Bronx, NY 10468. *On the fractional parts of roots of positive real numbers.*

Let $[\theta]$ denote the integer part and $\{\theta\}$ the fractional part of the real number θ . For $\theta > 1$ and $\{\theta^{1/n}\} \neq 0$, define $M_\theta(n) = [1/\{\theta^{1/n}\}]$. The arithmetic function $M_\theta(n)$ is eventually increasing, and $\lim_{n \rightarrow \infty} M_\theta(n)/n = 1/\log \theta$. Moreover, $M_\theta(n)$ is “linearly periodic” if and only if $\log \theta$ is rational. Other results and problems concerning the function $M_\theta(n)$, including connections with continued fractions, are discussed. (Received September 24, 2012)

1086-11-1951 **Karl Mahlburg*** (mahlburg@math.lsu.edu) and **Kathrin Bringmann**. *Asymptotic inequalities for positive rank and crank moments.*

Andrews, Chan, and Kim recently introduced a modified definition of crank and rank moments for integer partitions that allows the study of all moments, following Atkin and Garvan’s earlier study of even moments. The main result of this talk states that while the two families of moment functions are asymptotically equal, the crank moments are always asymptotically larger than the rank moments.

The generating functions include expressions involving false theta functions, and the proofs require the Circle Method along with other analytic techniques, such as Mittag-Leffler theory and Mellin transforms. (Received September 24, 2012)

1086-11-1957 **Jennifer Park*** (jmypark@math.mit.edu), 77 Massachusetts Avenue, Cambridge, MA 02139. *A symmetric version of Chabauty’s method on families of hyperelliptic curves.*

We will discuss how Chabauty’s method could be applied to families of hyperelliptic curves to obtain a bound on the number of non-trivial quadratic points on hyperelliptic curves. This can be combined with the recent result of Bhargava and Gross on the average rank of 2-Selmer groups of hyperelliptic curves, allowing one to describe the statistics of non-trivial quadratic points. (Received September 24, 2012)

1086-11-1962 **Abhinav Kumar*** (abhinav@math.mit.edu), Department of Mathematics, Rm 2-169, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, and **Henry Cohn** (cohn@microsoft.com), Microsoft Research New England, One Memorial Drive, Cambridge, MA 02142. *Metacommutation of Hurwitz primes.*

Conway and Smith, in their book “On Quaternions and Octonions”, studied factorization for integral (Hurwitz) quaternions, and introduced the metacommutation problem. Namely, if P and Q are prime Hurwitz integers of norms p and q (say) respectively, then $u = PQ$ also has a factorization of the form $u = Q'P'$, with Q' and P' of norms q and p respectively, unique up to unit-migration. They showed that factorization for the Hurwitz integers is unique up to the operations of unit-migration, metacommutation and recombination. The authors state that the problem of determining the metacommuting pair (Q', P') given (P, Q) does not seem to have been addressed in the literature. We study this question, and analyze some interesting properties of the metacommutation map. (Received September 24, 2012)

1086-11-1974 **Duff G. Campbell*** (campbell@hendrix.edu), Dept. of Mathematics and Computer Science, 1600 Washington Ave., Little Rock, AR 72212. *Patterns in continued fractions for \sqrt{n} .* Preliminary report.

In an undergraduate number theory course, I asked my students to find patterns in the continued fraction expansions of \sqrt{n} , working from a list of expansions for $n = 1$ to $n = 100$. Every time I assign this problem, students find the five “classic” patterns, for $n = m^2 \pm 1$, $n = m^2 \pm 2$, and $n = m^2 + m$. These patterns occur for every m . But one year, my students found some other patterns, which only occurred for even m , or odd m . They also found two patterns for m divisible by 3. Inspired by their efforts, I looked at the data myself, and found sixteen other patterns, each restricted to its own congruence class (mod M) with M ’s up to 27. In addition, I found other patterns where n had to satisfy a quadratic condition (such as n of the form $4k^2 + 3k + 1$). Together, these twenty-odd patterns cover \sqrt{n} for n up to 68, and 87 of the first hundred, etc. I have also found patterns in the continued fraction expansions of algebraic integers which are roots of $x^2 + x - n$. Here I have five patterns which apply to every n , fifteen that obey linear congruences, eight that satisfy quadratic congruences and two cubic congruences. Together, these patterns cover all n up to $n = 23$, sixty-eight of the first hundred, etc. (Received September 24, 2012)

1086-11-1982 **Daniel M Kane*** (dankane@math.stanford.edu). *The asymptotic number of partitions without k -sequences.*

The Rogers-Ramanujan identities relates the generating function for the number of partitions of n with no pair of parts of consecutive sizes and all sizes distinct, to the q -series of modular forms. Work of MacMahon provides a similar formula when the requirement of distinct sizes is dropped. When the condition that no pair of parts have

consecutive sizes is relaxed to the constraint that there are no k parts of consecutive sizes for some $k > 2$, things become considerably more difficult. Although the corresponding q -series can be written in relatively compact form obtaining the asymptotics of the coefficients has proved to be difficult. We present a new way of looking at this generating function as the limiting value of a recurrence relation and show how this can be used to obtain these asymptotics, thus establishing a conjecture of George Andrews. (Received September 24, 2012)

1086-11-2016 **Alyson Deines*** (adeines@math.washington.edu), 1011 NE 126th St, Seattle, WA 98125.
Computing Degrees of Parametrizations of Elliptic Curves by Shimura Curves.

Let E be an elliptic curve over \mathbb{Q} of conductor N . Then E has a modular parameterization, specifically there is a surjective morphism ϕ from the modular curve $X_0(N)$ to E . The degree of this map, m_E , is called the modular degree. There are many theorems and conjectures relating the modular degree m_E of an elliptic curve to the modular form f_E associated to E , of particular interest is the relation to congruence primes. Unfortunately, generalizing to number fields, we no longer always have modular curves. Takahashi and Ribet use the Jacquet-Langlands correspondence to parameterize elliptic curves over \mathbb{Q} by Shimura curves. I will examine how this generalizes to modular elliptic curves and in general modular abelian varieties over number fields. (Received September 25, 2012)

1086-11-2024 **Nathan Kaplan*** (nkaplan@math.harvard.edu) and **Noam Elkies** (elkies@math.harvard.edu). *Numerical Semigroups, t -core Partitions, and Weighted Theta Functions.*

A numerical semigroup is an additive submonoid S of \mathbb{N}_0 with finite complement. The size of the complement is the genus of S , $g(S)$, and the sum of the elements of the complement minus $g(S)(g(S) + 1)/2$ is the weight of S , $w(S)$. We use the theory of modular forms, specifically weighted theta functions, to show that for all $n \geq 6$ there is a numerical semigroup S with smallest nonzero element 5 and $w(S) + g(S) = n$.

This problem is motivated by the theory of t -core partitions, partitions with no hook lengths divisible by t . A theorem of Granville and Ono says that for any $t \geq 4$ and $n \geq 1$ there exists a t -core partition of n . Given a semigroup S with smallest nonzero element t we construct a t -core partition from it of size $w(S) + g(S)$. We express this quantity as a quadratic function in $t - 1$ variables. For $t = 5$, we study this function in detail and prove a stronger version of this result: for every $n \geq 6$ there exists a 5-core partition of n coming from a semigroup.

For $t = 5$ this function leads to a quadratic form related to the A_4 lattice. The condition that the inputs come from a semigroup leads us to restrict to inputs in a certain cone. We then study integers represented by these vectors using weighted theta functions. (Received September 24, 2012)

1086-11-2117 **Ekin Ozman***, ozman@math.utexas.edu. *Understanding Points on Twists.*

In this talk, I will present results about points on certain twists of the classical modular curve. Some of these twisted curves violate the Hasse principle and this violation is explained by the Brauer-Manin obstruction. In some other cases, it is possible to study Hasse principle violations via local-global trace obstructions. (Received September 24, 2012)

1086-11-2130 **Madeline Handschy** and **Katherine Meyer***, Box 8983, Smith College, Northampton, MA 01063, and **Katherine Phillips** and **Jennifer Sadler**. *Monoids Determined by a Linear Homogeneous Diophantine Equation*. Preliminary report.

Given nonzero integers a_1, a_2, \dots, a_n , we may consider the linear homogeneous Diophantine equation

$$a_1x_1 + a_2x_2 + \dots + a_nx_n = 0.$$

The set of n -tuples (x_1, x_2, \dots, x_n) which are solutions to this Diophantine equation form an abelian group under coordinate-wise addition. However, for many applications in algebra, one is only concerned with nonnegative solutions to the Diophantine equation. These nonnegative solutions form a monoid

$$M = M(a_1, a_2, \dots, a_n) = \{(x_1, \dots, x_n) \in \mathbb{N}_0^n \mid a_1x_1 + a_2x_2 + \dots + a_nx_n = 0\}.$$

Elements of these monoids may be factored into a sum of irreducible elements, i.e. elements of the monoid which cannot be written as a sum of two nonzero elements of the monoid. As with algebraic number rings, factorizations are not usually unique. Since these monoids are Krull, they have a divisor class group which controls the factorization. In our research, we expand upon earlier work of Chapman, Krause, and Oeljeklaus, which clarifies the relationship between the class group and the coefficients of certain Diophantine equations. We address this relationship more broadly, by relating the coefficients to factorization properties such as the elasticity. (Received September 24, 2012)

- 1086-11-2150 **Chad Awtrey*** (cawtre@elon.edu). *Computing Galois-theoretic invariants for certain degree six p -adic fields.*

Let K be a finite extension of the p -adic numbers with $p > 3$, and let L/K be a totally ramified sextic extension. For each of the sixteen transitive subgroups G of S_6 , we count the number of nonisomorphic extensions where the Galois group of the splitting field of L is equal to G . The technique is new and is based on the mass formulas of Krasner and Serre. (Received September 24, 2012)

- 1086-11-2167 **Abhinav Kumar*** (abhinav@math.mit.edu), Department of Mathematics, Rm 2-169, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, and **Henry Cohn**, **Christian Reiher** and **Achill Schürmann**. *Formally dual configurations in Euclidean space and in abelian groups.*

The Poisson summation formula allows us to prove a relation between the theta function of a lattice and of its dual. A natural question is the following: are there periodic structures which are “formally dual”, i.e. whose average theta functions are related by the same kind of relation? Examples of formally dual codes are known in the literature. We consider a stronger notion of formal duality: namely we say two periodic configurations \mathcal{P} and \mathcal{Q} in \mathbb{R}^n , each with one point per unit volume, are formal duals if for every Schwartz function f on \mathbb{R}^n , the average value of

$$E_f(x, \mathcal{P}) = \sum_{y \in \mathcal{P}, y \neq x} f(x - y)$$

over all $x \in \mathcal{P}$ is equal to the average value of $E_{\hat{f}}(z, \mathcal{Q})$ over all $z \in \mathcal{Q}$.

Examples of such structures were observed in numerical experiments of energy minimization for periodic packings done by Cohn, Kumar and Schürmann. In this talk we present some new examples of formal duals, by first translating to the language of finite abelian groups. We also show that some familiar periodic configurations, such as the Best packing in 10 dimensions, do not have formal duals, at least in our stronger sense. (Received September 24, 2012)

- 1086-11-2172 **Taylor Dupuy*** (taylor.dupuy@gmail.com). *A Torsor of Lifts of The Frobenius (in characteristic zero).*

Local sections of the first p -jet space of a variety over a p -adic ring give local lifts of the Frobenius. At least for curves of genus $g \geq 1$ it turns out that p -jet spaces admit the structure of a torsor under a line bundle. (Received September 25, 2012)

- 1086-11-2177 **George E Andrews** and **Song Heng Chan*** (chansh@ntu.edu.sg), Division of Mathematical Sciences, SPMS, Nanyang Technological University, 21 Nanyang link, Singapore, 637371, Singapore, and **Byungchan Kim**. *The odd moments of ranks and cranks.*

we modify the standard definition of moments of ranks and cranks so that odd moments no longer trivially vanish. We prove inequalities between the rank and crank moments. One consequence is that it gives an extension to F.G. Garvan’s result on the ordinary moments of ranks and cranks. We study a new counting function, $ospt(n)$, which is related to the smallest part partition function, $spt(n)$. (Received September 25, 2012)

- 1086-11-2188 **Keenan Monks** (monks@harvard.edu), **Sarah Peluse** (peluse@uchicago.edu) and **Lynnette Ye*** (lynnelle@stanford.edu). *Congruence Properties of Borchers Product Exponents.*

In his striking 1995 paper, Borchers found an infinite product expansion for certain modular forms with CM divisors. In particular, this applies to the Hilbert class polynomial of discriminant $-d$ evaluated at the modular j -function. Among a number of powerful generalizations of Borchers’ work, Zagier made an analogous statement for twisted versions of this polynomial. He proves that the exponents of these product expansions, $A(n, d)$, are the coefficients of certain special half-integral weight modular forms. We study the congruence properties of $A(n, d)$ modulo a prime ℓ by relating it to a modular representation of the logarithmic derivative of the Hilbert class polynomial. (Received September 25, 2012)

- 1086-11-2205 **Michael Rubinstein*** (michael.o.rubinstein@gmail.com), Pure Math, UW, 200 University Ave W, Waterloo, ON N2L3G1, Canada. *Identities for L -functions.*

I describe a variety of new identities for the Riemann zeta function, Hurwitz zeta function, and Dirichlet L -functions. These have application to high precision computation. (Received September 25, 2012)

1086-11-2283 **Mathew Rogers*** (mathewrogers@gmail.com), 743 Ave De L'epee, Outremont, QC H2V3V1, Canada. *New formulas for special values of the Ramanujan zeta function.*

Ramanujan's zeta function is defined by $\sum_{n=1}^{\infty} \frac{\tau(n)}{n^s}$, where $\tau(n)$ is the Ramanujan tau function. I will show how to prove new formulas for values outside of the critical strip, such as at $s=12$ and $s=13$. The method is based on an approach that was recently used to solve certain special cases of the Bloch-Beilinson conjectures for elliptic curves. (Received September 25, 2012)

1086-11-2307 **William A Stein*** (wstein@uw.edu), University of Washington, Seattle, WA 98122. *Elliptic curves over $\mathbf{Q}(\sqrt{5})$.* Preliminary report.

I will describe a speculative project to enumerate every elliptic curve over the field $\mathbf{Q}(\sqrt{5})$, up to the first curve of rank 4. We use an efficient implementation of an algorithm of Dembele and fast sparse linear algebra to compute tables of Hilbert modular forms of weight (2,2) over $\mathbf{Q}(\sqrt{5})$. Then, via a variety of methods, we construct the corresponding elliptic curves. To have any hope to someday reach our far-off goal, the implementations must be highly optimized; moreover, just keeping track of the enormous amount of data we generate is challenging. This is joint work with Jonathan Bober, Alyson Deines, Ariah Klages-Mundt, Benjamin LeVeque, R. Andrew Ohana, Sebastian Pancratz, Ashwath Rabindranath, Paul Sharaba, and Christelle Vincent. (Received September 25, 2012)

1086-11-2311 **William A Stein*** (wstein@uw.edu), University of Washington, Seattle, WA 98122, and **Jennifer Balakrishnan and Steffan Muller.** *What is p -adic BSD for abelian varieties?*

In 1986, Mazur, Tate, and Teitelbaum formulated a p -adic analogue of the Birch and Swinnerton-Dyer conjecture for elliptic curves over the rational numbers. This talk is about how to generalize their conjecture (in the good ordinary case) to higher dimensional modular abelian varieties over the rational numbers. I will discuss computational evidence for this more general conjecture in the case of modular hyperelliptic curves of genus 2. (Received September 25, 2012)

1086-11-2318 **Geoffrey Caveney, Jean-Louis Nicolas and Jonathan Sondow*** (jsondow@alumni.princeton.edu). *On SA, CA, and GA numbers.*

Gronwall's function G is defined for $n > 1$ by $G(n) = \frac{\sigma(n)}{n \log \log n}$ where $\sigma(n)$ is the sum of the divisors of n . We call an integer $N > 1$ a *GA1 number* if N is composite and $G(N) \geq G(N/p)$ for all prime factors p of N . We say that N is a *GA2 number* if $G(N) \geq G(aN)$ for all multiples aN of N . In "Robin's theorem, primes, and a new elementary reformulation of the Riemann Hypothesis," we used Robin's and Gronwall's theorems on G to prove that the Riemann Hypothesis (RH) is true if and only if 4 is the only number that is both GA1 and GA2. In the present paper, we study GA1 numbers and GA2 numbers separately. We compare them with superabundant (SA) and colossally abundant (CA) numbers (first studied by Ramanujan). We give algorithms for computing GA1 numbers; the smallest one with more than two prime factors is 183783600, while the smallest odd one is 1058462574572984015114271643676625. We find nineteen GA2 numbers ≤ 5040 , and prove that a GA2 number $N > 5040$ exists if and only if RH is false, in which case N is even and $> 10^{8576}$. Our paper is to appear in the Ramanujan Journal. (Received September 26, 2012)

1086-11-2323 **Alexander Berkovich*** (alex@ufl.edu). *On Certain Partition Inequalities.*

It is a well known corollary of the celebrated Rogers-Ramanujan identities that the coefficients in q -series expansion of the difference of two infinite products

$$1/(q, q^{4,5})_{\infty} - 1/(q^2, q^3; q^5)_{\infty}$$

are all non-negative.

Surprisingly, it is also true for the finite products

$$1/(q, q^{4,5})_L - 1/(q^2, q^3; q^5)_L, \quad L \text{ is integer } > 0.$$

In my talk I will discuss a simple injective argument due to Frank Garvan and myself that proves it.

Next, I review a new theorem by George Andrews: The q -series expansion of

$$1/(q, q^5, q^{6,5})_L - 1/(q^2, q^3, q^7; q^8)_L, \quad L \text{ is integer } > 0$$

has non-negative coefficients.

Finally, I discuss a recent generalization of this theorem by Keith Grizzell and myself :

For any $L > 0$ and any odd $y > 1$, the q -series expansion of

$$1/(q, q^{y+2}, q^{2y}; q^{2y+2})_L - 1/(q^2, q^y, q^{2y+1}; q^{2y+2})_L$$

has non-negative coefficients. (Received September 25, 2012)

1086-11-2342 **Suresh Venapally*** (suresh@mathcs.emory.edu), 400 Dowman dr, Math & Sci, Atlanta, GA 30322. *Degree three cohomology of function field of surfaces.*

Let F be the function field of a surface X over a finite field. Let l be a prime not equal to the characteristic of F . Suppose that F contains a primitive l^{th} root of unity. We prove a certain local-global principle for elements of $H^3(F, \mu_l)$ in terms of symbols in $H^2(F, \mu_l)$ with respect to the discrete valuations of F . We use this to prove that every element in $H^3(F, \mu_l)$ is a symbol. The local-global principle also leads to the vanishing of certain unramified degree 3 cohomology groups of conic fibrations over X . This has implications towards the validity of the conjecture that Brauer-Manin obstruction is the only obstruction to the existence of zero-cycles of degree one for certain surfaces over global fields of positive characteristic. (Received September 25, 2012)

1086-11-2358 **Katharine Chamberlin** and **Emma Colbert***, ercolb13@g.holycross.edu, **Sharon Frechette**, sfrechet@mathcs.holycross.edu, and **Patrick Heffernan, Rafe Jones** and **Sarah Orchard**. *Newly Irreducible Iterates of Some Families of Quadratic Polynomials.* Preliminary report.

Let K be a number field and for $f(x) \in K[x]$, let $f^n(x)$ denote the n th iterate of $f(x)$. Determining the factorization of $f^n(x)$ into irreducible polynomials has proven to be an important problem. In dynamics, it is a question about the inverse orbit $O^-(z) := \bigcup_{n \geq 1} f^{-n}(0)$ of zero, which has significance in various ways. (For instance, it accumulates at every point of the Julia set of f .) The field of arithmetic dynamics seeks to understand sets such as $O^-(z)$ from an algebraic perspective; finding factorizations of $f^n(x)$ fits into this scheme. A nontrivial factorization arises from an “unexpected” algebraic relation among elements of $O^-(z)$. In this talk, we discuss the two-parameter family of polynomials $g_{\gamma,m}(x) = (x-\gamma)^2 + m + \gamma$, for $\gamma, m \in K$, and give conditions under which the $(n+1)$ st iterate of $g_{\gamma,m}(x)$ is reducible when the n th iterate is irreducible. (We refer to such $g_{\gamma,m}^{n+1}(x)$ as *newly reducible*.) In particular, for $n \geq 2$, we show that under certain conditions on γ , there are only finitely many m for which $g_{\gamma,m}^{n+1}(x)$ is newly reducible. (These results are the product of an undergraduate summer research project at College of the Holy Cross.) (Received September 25, 2012)

1086-11-2388 **Trey Brock*** (trey.brock@gmail.com). *Diophantine Monoids Defined by a Single Linear Equation.* Preliminary report.

In this talk, we will consider factorization properties of diophantine monoids defined by a single linear equation with exactly one negative coefficient, that is $M = \ker \begin{bmatrix} a_1 & \dots & a_n & -b \end{bmatrix} \cap \mathbb{N}_0^{(n+1)}$ where a_1, \dots, a_n, b are positive integers. In particular, we utilize the block monoid of M to compute important factorization properties such as elasticity, the set of lengths and to enumerate the atoms of this monoid. (Received September 25, 2012)

1086-11-2401 **Robert C. Rhoades*** (rhoades@math.stanford.edu). *q-series and quantum modular forms.*

Mock and partial theta functions may be considered as duals of one another. For instance, many q -hypergeometric series equal a mock theta function for $|q| < 1$ and may be written as a partial theta function for $|q| > 1$. Quantum modular forms attempt to bridge the gap and exist when q is a root of unity. We will explain this phenomenon and give some connections to unimodal sequence and concave compositions. (Received September 25, 2012)

1086-11-2410 **Jonathan Webster*** (jwebste@butler.edu) and **Pieter Rozenhart**. *Exceptional Units in Cubic Function Fields.*

In this talk we study cubic function fields having exceptional units. We prove that the Galois fields are the immediate analogy of Shanks’ simplest cubic number fields. We prove for certain models that a cube-free polynomial discriminant is sufficient to guarantee that a root is a fundamental unit. We conjecture this criteria is sufficient. An existence of a counter example relies on the existence of particular fundamental units of quadratic function fields. (Received September 25, 2012)

1086-11-2467 **Barry R Smith*** (barsmith@lvc.edu). *Divisibility of the equivariant L-function value at zero for degree $2p$ extensions.* Preliminary report.

The equivariant L function value at zero of an Abelian extension of number fields K/k with Galois group G is an element of the rational group ring $\mathbb{Q}[G]$. Multiplying it by the number of roots of unity in K yields an element of the integral group ring $\mathbb{Z}[G]$, the “integralized L -value”. When p is an odd prime and K/k has degree $2p$, we show that the p -divisibility of the integralized L -value is usually determined in a simple way by the arithmetic of the quadratic extension of k contained in K . We also identify an extremely exceptional class of extensions K/k for which the situation is more complex; we conjecture that for such extensions, the p -divisibility of the integralized L -value is equivalent to a refinement of the Brumer-Stark conjecture for the quadratic sub-extension

of K/k whose top field is K . We prove this conjecture under the assumption that the Brumer-Stark conjecture holds for K/k . (Received September 25, 2012)

1086-11-2503 **Nathan Jones*** (ncjones@olemiss.edu), University of Mississippi, Hume Hall 305, P.O. Box 1848, University, MS 38677-1848, and **Ryan Daileida** (rdaileida@trinity.edu), San Antonio, TX. *An alternative view of primitivity of Dirichlet characters.*

Dirichlet characters and their associated L-functions were introduced by Dirichlet in his proof of the prime number theorem in arithmetic progressions. Recall that a Dirichlet character is called imprimitive if it is induced from a character of smaller level, and otherwise it is called primitive. In this talk, I will discuss a modification of “inducing to higher level” which causes imprimitive characters to behave primitively (e.g. the properties of the associated Gauss sum and the functional equation of the attached L-function take on a form usually associated to a primitive character). This is based on joint work with R. Daileida. (Received September 25, 2012)

1086-11-2513 **Eva Goedhart*** (egoedhart@brynawr.edu). *Solving the Diophantine equation $nx^2 + 2^\ell 3^m = y^n$.* Preliminary report.

Let $n > 3$ be an integer and consider the Diophantine equation

$$nx^2 + 2^\ell 3^m = y^n$$

with the requirements: $\ell, m, n \in \mathbb{N}$, $x, y \in \mathbb{Z}^+$, and $\gcd(nx, y) = 1$.

In 2011, Y. Wang, T. Wang, F. Luca, and G. Soydan demonstrated that the equation has no integer solutions when $m = 0$. Building on their work, I will outline the proof that the equation has no integer solutions for any positive integer values of ℓ and m . I will also discuss extensions to the result in which I prove $nx^2 + 3^m = y^n$ has no integer solutions for $n \not\equiv 7 \pmod{8}$ when m is even and $n \not\equiv 5 \pmod{8}$ when m is odd. The proofs depend on the parity of ℓ and m and a result of Yu.F. Bilu, G. Hanrot, and P.M. Voutier on defective Lehmer pairs. (Received September 25, 2012)

1086-11-2562 **Vipin S Menon** and **Ryan Paul Lawrence***, 3612 Dover Street, Lake Charles, LA 70607, and **Robert L Doucette**. *An exploration of the primality properties of Primitive Pythagorean Triplets.*

Prime numbers are a very essential part of cryptographic systems in computer security. Primitive Pythagorean triplets (PPTs) have been of interest to mathematicians for a long time. Our work explores the primality of the three numbers that make up a primitive pythagorean triplet, and investigates many such triplets of numbers. By writing a computer program in C for the same, we conduct a systematic study of the relative frequencies of 0-p, 1-p, 2-p and 3-p PPTs; where 0-p indicates the triplet has zero primes as in $\langle 21, 220, 221 \rangle$, 1-p indicates that the triplet has one prime number, as in $\langle 7, 24, 25 \rangle$, and 2-p indicates that the pythagorean triplet has two prime numbers as in $\langle 3, 4, 5 \rangle$. Our simulations indicate that there do not exist any 3-p PPTs (as is only to be expected). What we did not realize before the program ran was how the relative frequencies of the 0-p, 1-p, and 2-p PPTs would pan out. Preliminary results indicate that the 1-p PPTs are the dominant ones, because they are far more prevalent than the 0-p PPTs and the much less frequently seen 2-p PPTs. Our goals at the outset were to perform a number theoretic study of the topic, and an investigation to see if the observed pattern (observed by the computer simulation) could be backed up by results from Number Theory. (Received September 25, 2012)

1086-11-2581 **R. Scott Groth*** (finchc@wlu.edu), **Olivier Mahame**, **Jean Luc Mugabe**, **Braedon Suminski** and **Wenda Tu**. *Sierpiński numbers with special properties.* Preliminary report.

In 1960, Sierpiński used a covering of the integers to produce the first Sierpiński numbers. In this talk, we will report on findings from undergraduate summer research with Professor C. Finch regarding Sierpiński numbers that are also polygonal numbers, consecutive integers that are all Sierpiński, iterated Sierpiński numbers, and Sierpiński numbers in the sequences of generalized Finonacci numbers. (Received September 25, 2012)

1086-11-2590 **Colin J Weir*** (cjweir@ucalgary.ca), Calgary, Alberta, Canada. *Constructing Global and Non-Global Cubic Function Fields.*

We present a Kummer theoretic algorithm for constructing cubic function fields over a finite field \mathbb{F}_q with prescribed ramification. We then use this in a tabulation algorithm to construct all cubic function fields over \mathbb{F}_q up to a given discriminant bound and compare the data to known asymptotics. Moreover, we show how our construction techniques can be extended to characteristic zero to construct interesting curves over number fields. (Received September 25, 2012)

1086-11-2600 **Yoonbok Lee*** (lee@math.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627. *Fractional moments and density hypothesis of Hecke L -functions.*

Let $L(s)$ be a degree d L -function in the Selberg class. Let $N(\sigma, T)$ be the number of zeros of $L(s)$ in $\Re s > \sigma$ and $0 < \Im s < T$. The density hypothesis is $N(\sigma, T) \ll T^{1+c(1/2-\sigma)} \log T$ for $\sigma \geq 1/2$ and some $c > 0$. This is known only for small d . To understand the density hypothesis of $L(s)$ with large degree d , we investigate the fractional moment

$$I_k(\sigma, T) = \int_0^T |L(\sigma + it)|^{2k} dt$$

for small $k > 0$ and find some relations between $I_k(\sigma, T)$ and $N(\sigma, T)$. (Received September 25, 2012)

1086-11-2641 **Michael Filaseta*** (filaseta@math.sc.edu), Mathematics Department, University of South Carolina, Columbia, SC 29208. *A polynomial problem of Turán modulo primes.*

Turán asked whether there is an absolute constant C such that every polynomial $f(x) \in \mathbb{Z}[x]$ is within C of being an irreducible polynomial (meaning that there is a $w(x) \in \mathbb{Z}[x]$ with $\deg w \leq \deg f$ and with the sum of the absolute values of the coefficients of $w(x)$ at most C satisfying $f(x) + w(x)$ is irreducible over the rationals). As an application of covering systems, we will look at this problem modulo primes and give lower bounds on what such a C might be. In addition, we will survey computations that have been done that suggest these lower bounds are sharp. The original problem of Turán will be discussed in the context of these results modulo primes. (Received September 25, 2012)

1086-11-2644 **Diane Fenton*** (fentond@ucalgary.ca). *Divisibility properties of fourth order recurrent sequences.*

Divisibility properties of second order recurrent sequences are well studied and many of their properties are well understood owing to the theory of Lucas and Lehmer. For example, any prime number will divide some Fibonacci number. Analogous properties of fourth order sequences are more complicated and less studied. This talk will discuss some of these interesting properties based on work of R.K. Guy and H.C. Williams. (Received September 25, 2012)

1086-11-2646 **Clifton Cunningham and David Roe*** (roed.math@gmail.com). *Geometrizing quasi-characters of tori.*

Quasi-characters of tori appear in various contexts: class field theory, the local Langlands correspondence, and L -series. Let T be a torus over a non-archimedean local field K . We will give a description of the group $\text{Hom}(T(K), \mathbb{C}^\times)$ in terms of sheaves on a certain group scheme over the residue field of K . This is joint work with Clifton Cunningham. (Received September 25, 2012)

1086-11-2656 **Hanna Astephan, Solly Parenti, Joe Varilone, Nick Wasylyshyn and Ben Zinberg*** (bzinberg@mit.edu), 3 Ames St. #M508, Cambridge, MA 02142, and **Michael Zieve**. *Common Values of Polynomials Over Finite Fields.* Preliminary report.

Let K be the finite field of q elements, K_i its degree- i extension, and f and g polynomials in $K[x]$ of degree at most n . We provide several results and examples about the possibilities for N , where N is the cardinality of the intersection of the image sets $f(K)$ and $g(K)$. For instance, there are positive constants a_n and b_n , which depend only on n , such that either $N < 2n$ or $N > a_n q - b_n \sqrt{q}$. Moreover, if $f(K) = g(K)$ and q is larger than some explicit function of n , then there are infinitely many i for which $f(K_i) = g(K_i)$. If additionally f and g have prime degree, then there are very few possibilities for the monodromy group of f (which equals the monodromy group of g , except when f and g come from a known list of polynomials). By combining calculations inside the possible monodromy groups with factorization arguments, we obtain a partial classification of all such polynomials f and g . On the other hand, there are rational functions $f, g \in K(x)$ such that $f(K_i)$ equals $g(K_i)$ for even i , but $f(K_i)$ and $g(K_i)$ are disjoint for odd i . Our results depend on various ingredients, including deep group-theoretic results and a new function field analogue of the Frobenius Density Theorem. (Received September 25, 2012)

1086-11-2673 **Sankar Sitaraman*** (ssitaraman@howard.edu). *Mean values of certain multiplicative functions.* Preliminary report.

We estimate the mean values of certain multiplicative functions with values on the unit circle. We then discuss the applications of these estimates when combined with theorems of Erdős-Wintner, Delange et al. (Received September 25, 2012)

1086-11-2720 **Chris Hall*** (chall14@uwoyo.edu), **Jordan S. Ellenberg** and **Emmanuel Kowalski**.
Jumping ranks in families of elliptic surfaces.

We apply a joint result with J. Ellenberg and E. Kowalski to study the ranks in a one-parameter family of elliptic surfaces over Q . Given a family, we consider the Mordell-Weil rank of the generic fiber. We also consider the set E_d of algebraic parameters of degree at most d over Q and whose fibers have strictly larger Mordell-Weil rank. We show that if the family has big monodromy, then E_d is finite for every d , and we exhibit families with big monodromy. (Received September 25, 2012)

1086-11-2749 **Keenan Monks*** (monks@college.harvard.edu), 293 Dunster Mail Center, Cambridge, MA 02138-7544, and **Sarah Peluse** and **Lynnelle Ye**. *Strings of Special Primes in Arithmetic Progressions.*

The Green-Tao Theorem, one of the most celebrated theorems in modern number theory, states that there exist arbitrarily long arithmetic progressions of prime numbers. In a related but different direction, a recent theorem of Shiu proves that there exist arbitrarily long strings of consecutive primes that lie in any arithmetic progression that contains infinitely many primes. This presentation covers a research paper that, using the techniques of Shiu and Maier, generalizes Shiu's Theorem to certain subsets of the primes such as primes of the form $\lfloor \pi n \rfloor$ and some of arithmetic density zero such as primes of the form $\lfloor n \log \log n \rfloor$. (Received September 25, 2012)

1086-11-2758 **Zhu Cao*** (zcaospsu.edu), 1100 S Marietta Pkwy, Department of Mathematics, Southern Polytechnic State University, Marietta, GA 30060. *Ramanujan's forty identities for the Rogers-Ramanujan functions and further identities of the same type.* Preliminary report.

Ramanujan's lost notebook contains a list of forty identities for the Rogers-Ramanujan functions. In this talk, we give natural explanations for some of the identities in the forty identities. Some known identities as well as new identities are established as applications. (Received September 25, 2012)

1086-11-2809 **Kjell Wooding*** (kjell@wooding.org) and **H C Williams** (williams@math.ucalgary.ca), Dept. of Mathematics & Statistics, University of Calgary, 2500 University Dr NW, Calgary, AB T2N1N4, Canada. *On computing solutions to $fx^2 + gy^2 = m$.*

Consider the problem of finding $x, y \in \mathbb{Z}$ such that for a given $m, f, g \in \mathbb{Z}^+$, $fx^2 + gy^2 = m$. Define $t \in \mathbb{Z}$ to be a solution for $t^2 \equiv -gf^{-1} \pmod{m}$. In 1848, Hermite and Serret described an algorithm to solve for x and y when $f = g = 1$ using convergents in the simple continued fraction (SCF) expansion of t/m . In 1908, Cornacchia suggested an algorithm that could solve the problem for any f and g using only the remainders in the Euclidean Algorithm applied to t and m . An elementary exposition (due to Nitaj) proving the correctness of Cornacchia's algorithm did not follow until much later, and relied on a modified version of the algorithm which again requires finding the convergents in the SCF expansion of t/m . Our work shows that these convergents can be recovered, via elementary methods, from the sequence of remainders used by Cornacchia's original algorithm. (Received September 25, 2012)

1086-11-2859 **Peng Zhao*** (peng.zhao.pz62@yale.edu), Department of Mathematics, Yale University, New Haven, CT 06511. *Non-gaussian distribution in higher moments of matrix elements.* Preliminary report.

We study the distribution in higher moments of matrix elements for the modular surface. Our approach is via Watson's triple product formula, Kuznetsov trace formula and Rudnick-Soundararajan's technique to obtain a lower bound of higher moments of L -functions. It turns out that the higher moments of matrix elements does not follow the gaussian distribution. (Received September 25, 2012)

1086-11-2865 **Carmen M. Wright*** (carmen.m.wright@jsums.edu). *Some representation theory of $SL_*(2, \mathcal{O}/\mathfrak{p}^2)$ where $*$ is the identity and $SL_*(2, M_2(\mathcal{O}/\mathfrak{p}^2))$ where $*$ equals transpose.*

Let A be a ring with involution $*$. The "twisted" group $SL_*(2, A)$, defined by Pantoja and Soto-Andrade (2003), is a non-commutative version of $SL(2, F)$ where F is a field. Let \mathcal{O} be a local ring with prime ideal \mathfrak{p} and finite residue field \mathcal{O}/\mathfrak{p} . We consider the two groups $SL_*(2, \mathcal{O}/\mathfrak{p}^2)$ where $*$ is the identity and $SL_*(2, M_2(\mathcal{O}/\mathfrak{p}^2))$ where $*$ equals transpose. Each group contains a normal abelian subgroup such that certain irreducible representations of the group are non-trivial on that subgroup. We find these representations using Clifford's theorem. (Received September 25, 2012)

1086-11-2892 **Reyes Matiel Ortiz-Albino*** (reyes.ortiz@upr.edu), 1011 Sonsire Chalets, Mayaguez, PR 00682. *τ_n -Number Theory*. Preliminary report.

The study of a general theory of factorizations leads to the definition of a τ_n -factorization or τ_n -product, given by Anderson and Frazier, in 2006. They defined the concepts of τ_n -irreducible elements, τ_n -prime elements, and some properties of τ_n -factorizations. Later in 2007, Hamon characterized the τ_n -atomicity of \mathbb{Z} , which only holds for $n = 0, 1, 2, 3, 4, 5, 6, 8, 10$ and 12 . In 2008, Ortiz defined the greatest common τ_n -divisor, unfortunately it does not always exist for an integer $n > 1$. Nowadays, Ortiz has developed formulas to calculate a new type of ordered greatest common τ_n -divisor and some arithmetic τ_p -functions, where p is a positive prime integer. Even though the τ_n -gcd does not always exist, the ordered τ_n -gcd is conjectured to always exist for any natural number n . (Received September 26, 2012)

1086-11-2901 **Thao Do, Jared Hallet, Elliot Wells, Susan Yuhou Xia*** (yxia@brynmawr.edu) and **Michael Zieve**. *Polynomial Equations with Infinitely Many Solutions over an Algebraic Number Field*. Preliminary report.

In this paper, we will describe all polynomials F and G with algebraic coefficients for which the equation $F(X) = G(Y)$ has infinitely many solutions in some algebraic number field. This is equivalent to the following problem: Let \mathbb{K} be an algebraically closed field with characteristic zero. Classify all nonconstant $F(T), G(T) \in \mathbb{K}[T]$ such that $F(X) - G(Y)$ has an irreducible factor $H(X, Y) \in \mathbb{K}[X, Y]$ for which the curve $H(X, Y) = 0$ has genus zero or one. The discussion of the problem is divided into two cases: $F(X) - G(Y)$ is irreducible of genus 0 or 1 and $F(X) - G(Y)$ is reducible with an irreducible factor of genus 0 or 1. The classification of the irreducible case is done by using the Riemann-Hurwitz formula. We use monodromy groups of indecomposable polynomials and ramification to finish the classification of the reducible case. We are able to show that in most situations the reducible case does not happen. (Received September 26, 2012)

1086-11-2913 **Jose Martinez***, 2175 Dakota circle, Kingman, AZ 86401. *Trees of Irreducible Numerical Semigroups*. Preliminary report.

This presentation is based on research related to an algorithm for constructing a graph of irreducible numerical semigroups with a fixed Frobenius number, which was introduced in a paper by Blanco and Rosales. Certain open questions related to this algorithm are explored. (Received September 26, 2012)

1086-11-2925 **C. Sung***, 5201 University Boulevard, Laredo, TX 78041. *Some Recent Results on Odd Perfect Numbers*. Preliminary report.

A perfect number is a natural number N such that the sum of its positive divisors (including N) of N equals $2N$, denoted by $\sigma(N) = 2N$. From the work of Euclid and Euler, it is known that an even natural number N is perfect if and only if there is a natural number p such that $(2^p - 1)$ is a prime and $N = (2^p - 1)2^{p-1}$. Today, there are about 47 known even perfect numbers. Euler proved that for an odd perfect number N , there is a prime $p \equiv 1 \pmod{4}$ such that $N = (p^m)(q^2)$ with $m \equiv 1 \pmod{4}$ and $\gcd(p, q) = 1$. However, it is an unsolved problem in number theory whether there are any odd perfect numbers. In 1991, Brenti, Cohen, and de Riele proved that odd perfect numbers are greater than 10^{300} . In 2012, Ochem and Rao modified their method to show that odd perfect numbers are greater than 10^{1500} . Some recent results on odd perfect numbers will be discussed in this presentation. (Received September 26, 2012)

12 ► Field theory and polynomials

1086-12-368 **Martin Juras*** (martinj@qu.edu.qa), Department of Mathematics, College of Arts and Sciences, P O Box 2713, Qatar University, Doha, 2713, Qatar. *Irreducibility criteria for polynomials and linear transformations*.

Eisenstein, Eisenstein-Dumas, Schönemann, Stepanov-Schmidt irreducibility criteria and Newton polygon methods are all special cases of Newton polytopes method. Many irreducible polynomials may be detected by some of these criteria, only after certain linear change of variables. The author discovered that the search for this change of variables in case of Eisenstein and Eisenstein-Dumas criteria may be significantly simplified by looking at a certain "normal" form of the polynomial in question. This was proven for polynomials over unique factorization domains. Recently, Bishnoi and Khanduja (2010) extended this result to valued fields with arbitrary rank. For projective transformations, things get a little bit more complicated. (Received August 26, 2012)

1086-12-761 **David J Saltman*** (saltman@math.utexas.edu). *Finite u Invariant and Bounds on Cohomology Symbol Lengths.*

At an AIM workshop in January 2011, Parimala asked whether in a field with finite u invariant there was a bound on the “symbol length” of any element of μ_2 cohomology in any degree. We answer this question in the affirmative for fields of characteristic 0, and at the same time get bounds on the Galois groups that realize all the properties of these cohomology elements and show that our results extend to finite field extensions. (Received September 12, 2012)

1086-12-1356 **Abdon Eddy Choque Rivero*** (abdon@ifm.umich.mx), Hacienda San Diego 341, Frac. Hacienda del Valle, 58000 Morelia, Michoacan, Mexico. *The inverse boundary problem for two-velocity elastic networks.*

The in-plane motion of elastic strings on a tree-like network is considered. The two-velocity wave equation for a two component vector displacement is assumed to hold on each edge of a tree. We investigate the inverse problem of recovering the physical properties, i.e. the velocities and lengths of each string, and also the topology of the tree and the angles between branching edges. We extend the approach and result of the paper (S. Avdonin, G. Leugering and V. Mikhaylov, *On an inverse problem for tree-like networks of elastic strings*, Zeit. Angew. Math. Mech., **90** (2010), 136–150) to the case of variable velocities. It is shown that the inverse problem can be uniquely solved by applying measurements at all, or at all but one, boundary vertices. (Received September 21, 2012)

1086-12-1895 **Meghan M De Witt*** (dewitt@math.byu.edu), Provo, UT. *Minimal ramification and the Inverse Galois Problem over function fields.*

The Inverse Galois Problem is concerned with finding an extension of a field K with given Galois group. Here we consider the case where the base field is $K = \mathbb{F}_p(t)$ and give a conjectural formula for the minimal number of ramified primes in a G -extension of K . We provide a proof of this conjecture using embedding theory for all nilpotent groups. (Received September 24, 2012)

1086-12-2020 **Daniel R Krashen***, Department of Mathematics, University of Georgia, Athens, GA 30602. *Splitting dimension and symbol length in Galois cohomology.*

In this talk I will discuss how to bound symbol length using information on dimensions of splitting fields for elements in Galois cohomology and constructions of generic cocycles. (Received September 24, 2012)

1086-12-2170 **Matthew T Comer*** (mcomer@ncsu.edu), **Erich L Kaltofen** (kaltofen@math.ncsu.edu) and **Clément Pernet** (clement.pernet@imag.fr). *Sparse Polynomial Interpolation with Errors: Power and Shifted Bases.*

We discuss algorithms to solve two problems of sparse polynomial interpolation with errors. In the first problem, we recover a t -sparse polynomial $f(x)$ (in the power basis) from values $f(\omega^i)$, $i = 1, \dots, N$, where ω is a field element of our choice, and e values contain random/misleading errors. Our algorithm requires bounds $T \geq t$ and $E \geq e$, and $N = 2T(2E + 1)$; it is based on the interpolation algorithm of Prony (reformulated by Ben-Or and Tiwari).

In the second problem, we compute a shift s that will yield the sparsest representation of a polynomial $f(x)$ in the shifted power basis $(x - s)^k$, but from polynomials $f(\omega^i + z) \in \mathbb{F}[z]$. Here, the polynomials are interpolated densely, using Reed-Solomon error-correction, then the shift s and sparsity t are computed from the error-free “values” $f(\omega^i + z)$, where now $i = 1, \dots, 2T + 1$. The second step employs the results of Giesbrecht, Kaltofen, and Lee.

Both algorithms assume a black box for $f(x)$ that returns finitely many faulty values. In low dimension with few variables, multivariate sparse polynomials are handled by Kronecker substitution. With many variables, Zippel’s algorithm applies, but needs significantly more evaluation points. (Received September 25, 2012)

1086-12-2430 **Benjamin L Weiss*** (bweiss@bates.edu), Department of Mathematics, Hathorn Hall, Lewiston, ME 04140, and **Jeffrey C Lagarias**. *Splitting Behavior of Primes in S_n Extensions of \mathbb{Q} .* Preliminary report.

We will discuss the analysis of the probability that a random, monic, degree n polynomial in $\mathbb{Z}[x]$ with coefficients in a box of side B has splitting field with Galois group S_n and has prescribed Artin symbols (and is unramified) at finitely many given primes. The resulting distribution will be compared to conjectures of M. Bhargava (which are theorems for $n \leq 5$) asserting for any fixed prime p the proportion of number fields of degree n having Galois closure with group S_n and discriminant less than x with prescribed Artin symbol at p will have limiting density agreeing with the Chebotarev density theorem. (Received September 25, 2012)

- 1086-12-2434 **Benjamin L Weiss*** (bweiss@bates.edu), Mathematics Department, Hathorn Hall, Lewiston, ME 04240, and **Michael E Zieve**. *The Decomposition of Solutions to the Polynomial Pell Equation*.

We discuss a method of computing all decompositions of solutions $G(X)$ of the polynomial Pell equation $G(X)^2 - P(X)Q(X)^2 = 1$ with $\deg(P) = 4$. The techniques only require analyzing the ramification indices of $G(X) - T$ over $\mathbb{C}[T]$, and allow us to prove irreducibility results of $T_k(Y) - G(X) \in \mathbb{C}[X, Y]$ for Chebyshev polynomials T_k . We'll briefly discuss other previous methods of analyzing the decomposition of $G(X)$ by relating it to torsion points on elliptic curves. (Received September 25, 2012)

- 1086-12-2653 **Eric W Weisstein*** (eww@wolfram.com), 100 Trade Centre Dr, Champaign, IL 61820, and **Michael Trott** (mtrott@wolfram.com), 100 Trade Centre Dr, Champaign, IL 61820. *eCF: Encoding Continued Fraction Knowledge in Computational Form*. Preliminary report.

In this talk, we report progress toward collecting, semantically encoding, and exposing significant published results on continued fractions from the historical mathematical corpus as a digital library. This work, supported by the Sloan Foundation, extends the framework developed for the Wolfram—Alpha website to create a new type of free digital archive for mathematical data that will both ensure preservation and promote dissemination of a targeted segment of mathematical knowledge for the public good. Continued fractions are an ideal subject for this proof-of-concept as they constitute a subset of mathematics that is historically rich, well-defined, and nontrivial, yet at the same time manageable in scope. Work completed so far includes a nearly exhaustive collection of named and unnamed continued fraction identities, a normalized bibliographic database of ~ 500 relevant books and articles, and an initial collection of ~ 100 hand-curated theorems and results. All of these entities can be queried using a natural language syntax and provide additional linking and cross-entity entraining. In addition, many offer both visualizations and traditionally typeset versions, thus combining familiar traditional mathematical markup with modern tools for computational exploration. (Received September 25, 2012)

- 1086-12-2786 **Daniel C Smith*** (daniel-c.smith@louisville.edu). *Differential Invariants in Cryptography*.

The versatility of differential attacks in multivariate cryptography is a point of serious concern as the cryptographic community explores potential candidates for a quantum-resistant cryptosystems. We present some cryptosystems which have been broken with the discovery of techniques for solving discrete differential equations by finding anomalous differential invariants. We conclude proposing a route to providing a metric for differential invariant security. (Received September 25, 2012)

- 1086-12-2948 **Cemile Tosun*** (ctosun@siu.edu), Department of Mathematics, Southern Illinois University, 1245 Lincoln Drive Mail Code 4408, Carbondale, IL 62901. *Explicit Factorizations Of Generalized Cyclotomic Polynomials Over Finite Fields*.

We give explicit factorizations of generalized a -cyclotomic polynomials of order $3 \cdot 2^m$, into a product of irreducible polynomials for any nonzero a over a finite field F_q . (Received September 26, 2012)

13 ► Commutative rings and algebras

- 1086-13-117 **Elizabeth Gross*** (egross7@uic.edu), Department of Mathematics, 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60607-7045, and **Sonja Petrovic**. *Toric Ideals of Hypergraphs*.

Associated to any hypergraph is a toric ideal encoding the algebraic relations among its edges. We study these ideals and the combinatorics of their minimal generators. We give general degree bounds for the generators for both uniform and non-uniform hypergraphs. As an application, we show that the defining ideal of the tangential variety in cumulant coordinates is generated by quadratics and cubics. This is joint work with Sonja Petrovic. (Received July 24, 2012)

- 1086-13-193 **Ashley Rand*** (rand@math.utk.edu), University of Tennessee, Math Department, Knoxville, TN 37996. *Multiplicative Sets of Atoms*. Preliminary report.

It is well known that the multiplicatively closed set generated by the prime elements and units of an integral domain R is saturated. This means that if the product of two elements of R can be factored as a product of primes, then each of the two elements can be factored as a product of primes. In contrast, the multiplicatively closed set $\mathcal{A}(R)$ generated by the atoms (irreducible elements) and units of R need not be saturated. We investigate when the set $\mathcal{A}(R)$ is saturated. (Received August 06, 2012)

- 1086-13-194 **Silvia Saccon*** (ssaccon@math.arizona.edu), Department of Mathematics, The University of Arizona, Tucson, AZ 85721-0089, and **Nicholas R. Baeth**, Dept. of Mathematics and Computer Science, University of Central Missouri. *What does elasticity tell us about direct-sum behavior of torsion-free modules?*

In the last half century, there has been a lot of interest in the study of direct-sum behavior of finitely generated modules over commutative Noetherian local rings, and, more recently, in the interplay between direct-sum decompositions of modules and factorizations in commutative monoids. While every module is a direct sum of indecomposable modules, these decompositions need not be unique, and this behavior can be captured by the monoid of isomorphism classes of modules (with operation induced by the direct sum). In particular, monoid invariants, such as elasticity, are useful to understand how far direct-sum decompositions are from being unique. In this talk, I will introduce the monoid of isomorphism classes of finitely generated torsion-free modules, and discuss properties that will shed light on the direct-sum behavior of this class of modules. (Received August 13, 2012)

- 1086-13-247 **Courtney Gibbons*** (s-cgibbon50@math.unl.edu), Department of Mathematics, Lincoln, NE 68588-0130. *Betti diagrams of modules over short graded Gorenstein rings.*

Given a finitely generated module over a short graded Gorenstein ring, its Betti diagram alone determines some of its indecomposable direct summands. Further, it is possible to write this diagram as a rational sum of specially chosen Betti diagrams of modules over the same ring. My poster will further describe these results. (Received August 13, 2012)

- 1086-13-610 **Hailong Dao***, Department of Mathematics, University of Kansas, Lawrence, KS 66049. *Hochster's theta pairing and numerical equivalence.*

This is joint work with K. Kurano. Let R be a local hypersurface with an isolated singularity admitting a desingularization. We show that Hochster's theta pairing vanishes on elements in the Grothendieck group that are numerically trivial. As a consequence we show that the counter-example of Dutta-Hochster-McLaughlin to generalized Serre's vanishing exists when R is three dimensional and not a UFD. (Received September 08, 2012)

- 1086-13-646 **Susan E. Morey*** (morey@txstate.edu), Department of Mathematics, Texas State University, 601 University Dr., San Marcos, TX 78666. *Algebraic Properties of Square-free Monomial Ideals.*

In recent years, combinatorial representations of square-free monomial ideals, for example, edge ideals, clutter, or facet ideals, have proven fruitful in determining algebraic properties of the ideals. This talk will focus on classes of square-free monomial ideals that have a graphical representation, such as edge ideals or path ideals of a graph. The goal will be to use a combination of algebraic and combinatorial techniques to determine information about algebraic properties of these ideals, particularly those that are of interest in both commutative algebra and algebraic geometry, such as depths, Cohen-Macaulayness and associated primes. (Received September 10, 2012)

- 1086-13-779 **Craig Huneke*** (clhuneke@gmail.com), **Daniel Katz** and **Javid Validashti**. *Uniform Symbolic Topologies and Finite Extensions*. Preliminary report.

A Noetherian ring R is said to have uniform symbolic topologies for prime ideals if there exists a positive integer b such that for all prime ideals P and all $n \geq 1$ there is a containment between the symbolic powers and the usual powers of P :

$$P^{(bn)} \subset P^n.$$

The main question we are interested in is whether or not every complete local domain has uniform symbolic topologies for prime ideals. In this talk we discuss how this property behaves under finite extensions. (Received September 12, 2012)

- 1086-13-847 **Byung Gyun Kang*** (bgkang@postech.ac.kr), Dept. of Math., POSTECH, Pohang, South Korea, and **Phan Thanh Toan** (pttoan@postech.ac.kr), Dept. of Math., POSTECH, Pohang, South Korea. *Noetherian property of subrings of power series rings.*

Let R be a commutative ring with unit. Let X and Y be sets of indeterminates over R . We study subrings $R[X; Y, f]$ of $R[X][[Y]]$, where f is a nonnegative real-valued increasing function. These rings $R[X; Y, f]$ are obtained from elements of $R[X][[Y]]$ by bounding their total X -degree above by f on their Y -degree. Such rings naturally arise from studying p -adic analytic variation of zeta functions over finite fields. Under certain conditions, Wan and Davis showed that if R is Noetherian, then so is $R[X; Y, f]$. In this paper we give an equivalent condition for $R[X; Y, f]$ to be a Noetherian ring when Y has more than one variable and f grows at least as fast as linear. It

turns out that the ring $R[X;Y,f]$ is not Noetherian for a quite large class of functions f including the functions that were asked about by Wan. (Received September 13, 2012)

1086-13-910 **David de@msri.org Eisenbud*** (de@msri.org), 2 Ajax Place, Berkeley, CA 94708, and **Irena Peeva** (ivp1@cornell.edu). *High syzygy modules over complete intersections.* Preliminary report.

The minimal resolution of a Cohen-Macaulay module over a hypersurface ring is well-understood, and some information about the codimension 2 case was obtained by Avramov and Buchweitz, but for general codimension the situation has been mysterious. I will describe recent joint work with Irena Peeva that bears on the problem of describing such minimal resolutions in all codimensions. (Received September 15, 2012)

1086-13-966 **Nicholas R. Baeth** and **Roger Wiegand*** (rwiegand@unl.edu), 203 Avery Hall, University of Nebraska, Lincoln, NE 68588-0130. *Factorization theory and decompositions of modules.*

Let (R, \mathfrak{m}) be a Noetherian local integral domain and $\mathfrak{C}(R)$ the additive monoid of isomorphism classes of maximal Cohen-Macaulay R -modules (together with 0), with addition induced by the direct sum. We will make some general remarks about these monoids (they are, for example, always Krull monoids) and then specialize to the case $\dim R = 1$, where we know a great deal about their structure. We know, for example, that $\mathfrak{C}(R)$ is factorial if the completion \hat{R} is an integral domain and usually (but not always) has infinite elasticity otherwise. (Received September 17, 2012)

1086-13-990 **Marco Fontana*** (fontana@mat.uniroma3.it), Dipartimento di Matematica, Università degli Studi, "Roma Tre", 1, Largo San Leonardo Murialdo, 00146 Roma, RM, Italy. *Some remarks on ideal factorizations in Prüfer domains.*

I will present some recent results on ideal factorizations in Prüfer domains obtained in joint works with Evan Houston and Tom Lucas. (Received September 17, 2012)

1086-13-1077 **Saeed Nasseh*** (saeed.nasseh@ndsu.edu), Department of Mathematics, North Dakota State University, Fargo, ND 58108, and **Sean Sather-Wagstaff**. *DG homological algebra and solution to a question of Vasconcelos.*

A homologically finite complex C over a commutative noetherian ring R is *semidualizing* if $\mathbf{R}\mathrm{Hom}_R(C, C) \simeq R$ in $\mathcal{D}(R)$. In this talk, we answer a question of Vasconcelos from 1974 by showing that a local ring has only finitely many shift-isomorphism classes of semidualizing complexes. Our proof relies on certain aspects of deformation theory for DG modules over a finite dimensional DG algebra. (Received September 18, 2012)

1086-13-1216 **Michelle Knox*** (michelle.knox@msu.edu), **Papiya Bhattacharjee** and **Warren Wm. McGovern**. *p -Embeddings.*

Let R be a commutative ring with identity. A ring extension $R \hookrightarrow S$ is called a p -extension if for every $s \in S$ there is an $r \in R$ such that $sS = rS$, i.e., every principally generated ideal of S is generated by an element of R . The extension is called an associate p -extension if for every $s \in S$ there is an $r \in R$ and a unit $u \in S$ such that $r = su$. We will discuss some of the theory behind (associate) p -extensions and applications to $C(X)$, the ring of continuous functions. (Received September 20, 2012)

1086-13-1258 **Simplicio Tchamna*** (tchamna@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, P.O. Box 30001, Department 3MB, Las Cruces, NM 88001. *Connections between the ideal completion and the m -adic completion of a Noetherian Local Domain.*

The ideal topology on a commutative ring R is the topology which has a fundamental system of neighborhoods of 0 the nonzero ideals of R . Matlis used the ideal topology in his studies of torsion-free and cotorsion modules. We investigate the properties of the ideal topology on a Noetherian local domain (R, \mathfrak{m}) , and we establish connections between the m -adic topology and the ideal topology. We will present the relations between the ideal completion and the m -adic completion of a local Noetherian domain. In particular, we will discuss the properties satisfied by one completion and not the other. We give conditions under which the completion in the ideal topology is Noetherian and we show that unlike the m -adic completion, the completion in the ideal topology is not always Noetherian. (Received September 20, 2012)

- 1086-13-1281 **Irena Swanson*** (iswanson@reed.edu), Reed College, 3203 SE Woodstock Blvd, Portland, OR 97202, and **Amelia Taylor**, Colorado College, Colorado Springs, CO 80903. *Structure of certain conditional independence ideals*. Preliminary report.

The motivation for this work was the paper of Fink answering a conjecture of Cartwright and Engstrom regarding the structure of certain conditional independence ideals. We generalize Fink's work to any finite number of discrete random variables: we determine the structure of the minimal prime ideals, and we have partial results on the embedded prime ideals. Related to these ideals is a switching game that will also be presented in the talk. (Received September 20, 2012)

- 1086-13-1343 **Lance Edward Miller*** (lmiller@math.utah.edu), **Kazuma Shimomoto** and **Jun Horiuchi**. *Sufficient conditions for F -injectivity to deform*. Preliminary report.

It is a long standing conjecture that F -injectivity deforms. In this talk, we discuss some simple criteria on local cohomology sufficient to give that F -injectivity deforms. These will apply to show that F -injectivity deforms when the non-CM locus of the special fiber is isolated and combining with recent work of L. Ma, it will show that F -purity deforms to F -injectivity. (Received September 21, 2012)

- 1086-13-1397 **Bernadette Boyle*** (boyleb7@sacredheart.edu), Department of Mathematics, Sacred Heart University, 5151 Park Avenue, Fairfield, CT 06825. *The Unimodality of Pure O -Sequences of Type Two in Four Variables*.

A pure O -sequence is a vector which counts the monomials, in each degree, of a pure monomial order ideal; alternatively, it is the Hilbert function of a level artinian monomial algebra. It has long been known that pure O -sequences are not necessarily unimodal. However, it is interesting to ask if there are restrictions that we can place on such an algebra which force the Hilbert function to be unimodal. In this talk we will focus on monomial level algebras in four variables with type two, and show that their Hilbert functions are always unimodal. (Received September 21, 2012)

- 1086-13-1504 **Christopher A Francisco*** (chris@math.okstate.edu), **Jeffrey Mermin** and **Jay Schweig**. *Generalizing the Borel property*.

We introduce the notion of a monomial ideal being Borel with respect to a poset, a generalization of the usual Borel condition. We argue that the closer the poset is to the chain of maximal length, the more the ideal should behave like an ordinary Borel ideal. In some special cases, we demonstrate computing some invariants of monomial ideals using this poset-Borel framework. (Received September 22, 2012)

- 1086-13-1530 **Yu Xie*** (xieyucn@gmail.com), 750 COE, 7th floor, 30 Pryor Street, Atlanta, GA 30303. *Formulas for the generalized Hilbert Coefficients*.

Let (R, m) be a Cohen-Macaulay local ring of dimension d . In 1996, S. Huckaba provided a d -dimensional version of 2-dimensional formula due to C. Huneke in 1987, which relates the length $\lambda(I^{n+1}/JI^n)$ to the difference $P_I(n+1) - H_I(n+1)$, where I is an m -primary ideal of R , J is a minimal reduction of I , $H_I(n) = \lambda(R/I^n)$, and $P_I(n)$ is the Hilbert-Samuel polynomial of I . S. Huckaba also used this formula to establish some formulas for the higher Hilbert coefficients of I . We extend S. Huckaba's work further to non m -primary ideals. (Received September 23, 2012)

- 1086-13-1596 **Kuei-Nuan Lin** and **Jason McCullough*** (jmccullough@msri.org). *Hypergraphs and Regularity of Squarefree Monomial Ideals*. Preliminary report.

We define a new combinatorial object, which we call a labeled hypergraph, associated to every squarefree monomial ideal. Using this new object, we derive combinatorial ways of computing formulas for Castelnuovo-Mumford regularity of large classes of squarefree monomial ideals. We also obtain more general upper bounds and some tighter results for one-dimensional hypergraphs. (Received September 23, 2012)

- 1086-13-1628 **Jim Coykendall*** (jim.coykendall@gmail.com), Department of Mathematics, North Dakota State University, Fargo, ND 58108. *Atomicity and Near Atomicity*.

We say that an integral domain is atomic if every nonzero, nonunit can be written as a product of irreducible elements (atoms). In this talk we will look at atomic, "nearly atomic", and more specialized conditions from a number of points of view (both element-wise and graph-theoretic). We will also delve into some of the difficulties encountered when the assumption "integral domain" is removed. (Received September 23, 2012)

- 1086-13-1647 **Paul Baginski*** (pbaginsk@smith.edu), Department of Mathematics and Statistics, Smith College, 44 College Lane, Northampton, MA 01063. *Full Elasticity in Atomic Monoids*. Preliminary report.

In an atomic integral domain or atomic monoid, elements may have several different factorizations into irreducibles. The elasticity of an element gives one measure of the “non-uniqueness” of these factorizations. Specifically, if x is a nonunit of an atomic monoid M , the length set of x is the set

$$\mathcal{L}(x) := \{n \in \mathbb{N} \mid \exists a_1, \dots, a_n \in M \text{ irreducible such that } x = a_1 \cdots a_n\}.$$

The elasticity of x is the ratio $\rho(x) := \sup \mathcal{L}(x) / \min \mathcal{L}(x)$. The elasticity of the monoid M is defined as the supremum of elasticities of elements, namely $\rho(M) := \sup_{x \in M} \rho(x)$. The elasticity of the monoid gives a worst-case scenario of the degree of non-uniqueness across the monoid; we are interested in determining whether all intermediate degrees of non-uniqueness are also achieved. If so, the monoid is said to be fully elastic. We will relate full elasticity to several known properties of monoids and consider several broad classes of test cases, including Krull monoids, finitely generated monoids, and congruence monoids. (Received September 23, 2012)

- 1086-13-1668 **Olgur Celikbas*** (celikbas0@missouri.edu), Mathematics Department, 323 Mathematical Sciences Bldg., University of Missouri-Columbia, Columbia, MO 65211, and **Srikanth Iyengar** (s.b.iyengar@unl.edu), **Greg Piepmeyer** (ggpz95@mail.missouri.edu) and **Roger Wiegand** (rwiegand@unl.edu). *An application to the vanishing of $\eta(-, -)$ pairing*. Preliminary report.

Let R be a commutative Noetherian local complete intersection ring of codimension c , and let M and N be nonzero finitely generated R -modules such that $\text{Tor}_{\geq 0}^R(M, N)$ has finite length. Assume $c \geq 2$ and that $\eta_c^R(M, N) = 0$ (Here $\eta(-, -)$ is a generalized version of Hochster’s $\theta(-, -)$ pairing, initially defined and studied by Hailong Dao.) We give various criteria, in terms of the depth properties of M , N , and $M \otimes_R N$, that force the vanishing of $\text{Tor}_{\geq 0}^R(M, N)$. Applying our result to a class of complete intersections over which $\eta(-, -) = 0$, we obtain a new connection between the torsion in the tensor product of modules and the vanishing of Tor . (Received September 24, 2012)

- 1086-13-1759 **Thomas Dunn*** (thomas.dunn@ndsu.edu), NDSU Mathematics Dept #2750, North Dakota State University, PO Box 6050, Fargo, ND 58108. *A Linear Formula For the Generalized Multiplicity Sequence*.

For an arbitrary ideal I in a local ring R and an R -module M , Achilles and Manaresi introduced the sequence of generalized multiplicities $c_k(I, M)$ ($k = 0, \dots, \dim M$) as a generalization of the classical Samuel multiplicity $e(I, M)$ of an \mathfrak{m} -primary ideal I . We prove a formula expressing each generalized multiplicity $c_k(I, M)$ as a linear combination of certain local multiplicities $c_0(IR_{\mathfrak{p}}, M_{\mathfrak{p}})$. As a consequence, when M is formally equidimensional, we prove that if $I \subseteq J$ and $c_k(I, M) = c_k(J, M)$ for all $k = 0, \dots, \dim M$ then I is a reduction of (J, M) . The converse of this statement is also known to be true by a result of Ciupercă. This theorem gives a complete numerical characterization of integral closure, generalizing a well known theorem of Rees. (Received September 24, 2012)

- 1086-13-1822 **Adam Boocher***, aboocher@math.berkeley.edu. *Resolutions of Sparse Determinantal Ideals*.

In 1982, Giusti and Merle studied matrices whose entries are distinct variables and zeros. In particular, they studied the ideal of maximal minors, and showed that many invariants depended only on the size of the biggest rectangle of zeros. In this talk, I’ll present a technique for computing the minimal free resolution of these ideals. As a consequence we can show that the ideals studied by Merle and Giusti all have a linear resolution, and that the projective dimension depends only on the number of columns of the matrix which are identically zero. Along the way, we’ll discuss related questions - Gröbner bases, initial ideals, and their free resolutions. (Received September 24, 2012)

- 1086-13-1879 **Courtney Gibbons*** (s-cgibbon5@math.unl.edu). *Modules over short Gorenstein rings*. Preliminary report.

Given a finitely generated module over a short graded Gorenstein ring, its Betti diagram alone is enough to determine some of its indecomposable direct summands. As with cosyzygies of the residue field, some indecomposable Koszul modules can be recognized from a small amount of data. The author also demonstrates the existence of Koszul modules for given Hilbert series. (Received September 24, 2012)

1086-13-1880 **Benjamin J Anderson*** (banderson@uwlax.edu), Mathematics Department, 1020 Cowley Hall, 1725 State Street, La Crosse, WI 54601. *NAK for Ext, Ascent of Module Structures and the Blindness of Extended Modules*. Preliminary report.

Let $\varphi: R \rightarrow S$ be a flat local ring homomorphism, and let M be a finitely generated R -module. Then the following are equivalent:

- (1) M has an S -module structure compatible with its R -module structure;
- (2) $\text{Ext}_R^i(S, M) = 0$ for $i \geq 1$;
- (3) $\text{Ext}_R^i(S, M)$ is finitely generated over R for $i = 1, \dots, \dim_R(M)$;
- (4) $\text{Ext}_R^i(S, M)$ is finitely generated over S for $i = 1, \dots, \dim_R(M)$;
- (5) $\text{Ext}_R^i(S, M)$ satisfies NAK over R for $i = 1, \dots, \dim_R(M)$.

We will discuss this result, some generalizations of this result, and demonstrate equalities between a number of invariants computed over R and over S for modules that satisfy the equivalent conditions stated above. (Received September 24, 2012)

1086-13-1971 **Alina A Florescu*** (alina-florescu@uiowa.edu). *Reduced τ_n -factorizations of the Integers*. Preliminary report.

Given a natural number n , a reduced τ_n -factorization of an integer a is a factorization of the type

$$a = a_1 a_2 \dots a_k,$$

where $a_1 \equiv a_2 \equiv \dots \equiv a_k \pmod{n}$ and $a_i \neq \pm 1$ for all $1 \leq i \leq k$. With these generalized factorizations new irreducible elements emerge. For example, for $n \geq 2$, $6 = 2 \cdot 3$ has no nontrivial reduced τ_n -factorizations. The analogue of the Fundamental Theorem of Arithmetic, that any positive integer has a unique reduced τ_n -factorization into these new irreducibles, fails in the existence part for most n . For the remaining n , the uniqueness of the factorization is not guaranteed. (Received September 24, 2012)

1086-13-2014 **Jesse Burke*** (jburke@math.ucla.edu), Los Angeles, CA 90095, and **Mark E Walker** (mwalker5@math.unl.edu), Lincoln, NE, NE 68588. *Matrix factorizations over projective schemes*.

We will discuss matrix factorizations of global sections of line bundles on schemes. These objects are a generalization of the matrix factorizations introduced by Eisenbud in 1980, and have been studied recently by several groups of people. If the line bundle is very ample relative to a Noetherian affine scheme, homomorphisms in the homotopy category of matrix factorizations may be computed as the hypercohomology of a certain mapping complex. This explicit description is used to show that there is a fully faithful embedding of the homotopy category of matrix factorizations into the singularity category of the corresponding zero subscheme. (Received September 24, 2012)

1086-13-2187 **Ananth Hariharan, Craig Huneke and Javid Validashti*** (jvalidas@illinois.edu). *Lech's Inequality*. Preliminary report.

Let R be a Noetherian local ring with maximal ideal \mathfrak{m} and dimension d . For an \mathfrak{m} -primary ideal I in R , Lech has shown that $e(I) \leq d! \lambda(R/I)e(R)$, where $e(-)$ denotes the Hilbert-Samuel multiplicity and $\lambda(-)$ denotes the length. One can argue that asymptotically this inequality is sharp, but in general it gives a very weak bound for $e(I)$. In a joint work with H. Hariharan and C. Huneke, we explore refinements of the Lech's inequality and the consequent inequalities on the Hilbert coefficients of I . (Received September 25, 2012)

1086-13-2210 **Ben Richert*** (brichert@calpoly.edu), Mathematics Department, Cal Poly, San Luis Obispo, CA 93407. *Partitionable Simplicial Complexes*. Preliminary report.

A simplicial complex Δ is said to be partitionable if there exists a partition $\Delta = \cup_{i=1}^r [F_i, G_i]$ where the G_i are the facets of Δ and $[F_i, G_i] = \{F \in \Delta \mid F_i \subseteq F \subseteq G_i\}$. Stanley has conjectured that if Δ is Cohen-Macaulay then Δ is partitionable. We assume this conjecture and explore some of the implications.

If Δ is a pure simplicial complex of dimension n on v vertices, we define $C_{(n-1)}(\Delta)$ to be the simplicial complex on one more vertex $v+1$ such that $\{i_1, \dots, i_k\} \in C_{(n-1)}(\Delta)$ if and only if either $\{i_1, \dots, i_k\} \in \Delta$ or $i_k = v+1$, $\{i_1, \dots, i_{k-1}\} \in \Delta$ and $k-1 \leq n-1$. Let $C_{n-1}^t(\Delta)$ be the t -fold application of this procedure. Then we prove that $\min\{t \mid C_{n-1}^t(\Delta) \text{ is partitionable}\} = \dim(k[\Delta]) - \text{depth}(k[\Delta])$ where $k[\Delta]$ is the Stanley-Reisner ring of Δ . (Received September 25, 2012)

1086-13-2275 **Mark E Walker*** (mwalker5@unl.edu), 203 Avery Hall, Lincoln, NE 68588. *The homotopy theory of matrix factorizations*. Preliminary report.

I will describe how a Quillen model category structure for matrix factorizations (due to Positselski) leads to a definition of Hochschild homology and the construction of Chern characters for matrix factorizations. This

represents a generalization and an abstraction of such constructions worked out already in special cases by Polishchuk-Vaintrob, Carqueville-Murfet, and Dyckerhoff-Murfet. (Received September 25, 2012)

1086-13-2428 **Sean Sather-Wagstaff** and **Richard Wicklein*** (richard.wicklein@ndsu.edu).
I-Codualizing Modules. Preliminary report.

Let R be a commutative, noetherian ring. A finitely generated R -module C is said to be semidualizing if $\text{Ext}_R^i(C, C) = 0$ for all $i > 0$ and $R \xrightarrow{\cong} \text{Hom}_R(C, C)$. When R is local, an artinian R -module T is said to be quasidualizing if $\text{Ext}_R^i(T, T) = 0$ for all $i > 0$ and $\widehat{R} \xrightarrow{\cong} \text{Hom}_R(T, T)$. Using the notion of I -cofiniteness, we introduce a unifying notion that recovers each of the above notions as special cases. (Received September 25, 2012)

1086-13-2450 **Uwe Nagel** (uwe.nagel@uky.edu) and **Augustine B. O’Keefe*** (abok222@uky.edu).
Multidegree of toric ideals. Preliminary report.

The multidegree of an ideal is a multigraded generalization of the degree of a \mathbb{Z} -graded ideal. These multidegrees can provide insight into the combinatorial data related to the ideal. For example, in the case of the classical determinantal ideal the multidegree is in fact a Schur polynomial. In this talk we aim to present similar connections for more general toric ideals. (Received September 25, 2012)

1086-13-2532 **Gwyneth R Whieldon*** (whieldon@hood.edu), 401 Rosemont Avenue, Frederick, MD 21701. *Betti Numbers of Infinite Free Resolutions*. Preliminary report.

Let R be a polynomial ring over a characteristic zero field \mathbb{k} in n indeterminates and I be an ideal. Examining the properties of the infinite graded resolution of the residue field over $S = R/I$ is difficult, even in the special cases where I is a complete intersection, toric ideal, or monomial ideal. In particular, providing explicit formulas for either the Betti numbers or the Poincare series of such resolutions can be difficult.

For certain classes of monomial ideals however, the Betti numbers of the resolution satisfy very nice recursion formulas. For example, the Betti numbers of the resolution of \mathbb{k} over $S = \mathbb{k}[x, y]/(x^2, xy)$ are given by $\beta_i(S) = F_i$, where F_i is the i th Fibonacci number. Using results of Jollenbeck and Welker, we construct classes of ideals with given recursion formulas, and give a method to construct, for classes of linear recursion formulas $r_i = \alpha_{i-1}r_{i-1} + \dots + \alpha_j r_j$, a monomial ideal $\mathfrak{a} \subset \mathbb{k}[x_1, \dots, x_n]$ with Betti numbers $\beta_i(\mathbb{k}[x_1, \dots, x_n]/\mathfrak{a}) = r_i$. (Received September 25, 2012)

1086-13-2553 **Ananthnarayan Hariharan** (ahariharan2@math.unl.edu), **Paolo Mantero*** (pmantero@msri.org) and **Alexandra Seceleanu** (aseceleanu2@math.unl.edu).
Constructing some classes of Gorenstein rings via connected sums.

A construction recently introduced by L. Avramov, A. Hariharan and F. Moore allows one to produce a new Gorenstein local ring starting from three Gorenstein local rings R , S and T . This new ring is called a connected sum of R and S over T . The main question is: What Gorenstein (Artinian) local rings arise in this way?

E. Celikbas, A. Hariharan and Y. Zheng have shown that every stretched or short Gorenstein Artinian local k -algebra arises as a connected sum over a field $T = k$. In this talk we show that, slightly more complicated choices of T allow us to realize more general classes of Gorenstein local k -algebras as connected sums over T . We also show that connected sums over these more complicated T can have a much wilder behavior than the connected sums over k . (Received September 25, 2012)

1086-13-2739 **Amanda Croll***, Dept. of Mathematics, University of Nebraska-Lincoln, P.O. Box 880130, Lincoln, NE 68505. *Periodic modules over a Gorenstein local ring*. Preliminary report.

In 1990, Avramov posed the following problem: characterize the rings that have a periodic module, which is defined to be a module with a periodic minimal free resolution. It is proved that a complete Gorenstein local ring has such a module if and only if there is nontrivial torsion in a certain $\mathbb{Z}[t, t^{-1}]$ -module associated to the ring. This module, which we denote $J_R(t)$, is the free $\mathbb{Z}[t, t^{-1}]$ -module on the isomorphism classes of finitely generated R -modules modulo relations reminiscent of those defining the Grothendieck group of R . The main result is a structure theorem for $J_R(t)$ when R is a complete Gorenstein local ring; the link between torsion and existence of a periodic module is a corollary. (Received September 25, 2012)

1086-13-2747 **Tyler A Russell*** (tyler.russell@ttu.edu), **Jennifer Graetz** and **Steven Deckelman**.
A Multiplicative Analogue of the Reynolds Operator and Construction of Invariants. Preliminary report.

We explore multiplicative analogue of the Reynolds operator that first arose in CR geometry. Comparisons with the classical Reynolds operator are made in connection with the problem of computing algebra generators in invariant rings over \mathbb{C} . (Received September 25, 2012)

1086-13-2915 **Jennifer Biermann*** (jvbierma@lakeheadu.ca), **Christopher Francisco**, **Huy Tai Hà** and **Adam Van Tuyl**. *Colorings of simplicial complexes and vertex decomposability.*

In attempting to understand how combinatorial modifications alter algebraic properties of monomial ideals, several authors have investigated the process of adding “whiskers” to graphs. The first and the fourth authors developed a similar construction to build a vertex decomposable simplicial complex Δ_χ from a coloring χ of the vertices of a simplicial complex Δ . In this paper, we study this construction for colorings of subsets of the vertices. Using combinatorial topology, we strengthen and give new proofs for results of the second and third authors that were originally proven using algebraic techniques. (Received September 26, 2012)

14 ► Algebraic geometry

1086-14-122 **David J. Bruce*** (djbruce@umich.edu), 604 S. State St, Ann Arbor, MI 48104, and **Evan D. Nash**, **Ben Perez** and **Pete Vermeire**. *Betti Tables of Reducible Algebraic Curves.*

We study the Betti tables of reducible algebraic curves, focusing our attention on connected *line arrangements*, curves comprised of intersecting linear components. We provide a general formula for the quadratic strand of the Betti table for any line arrangement satisfying mild hypotheses. Building upon this result we give explicit formulas for the entries of the Betti tables for all curves of arithmetic genus zero or one. Finally, we give explicit formulas for the Betti numbers for a large class of curves of higher genus, as well as prove some general results on how the Betti numbers change when the line arrangements are modified. (Received July 25, 2012)

1086-14-150 **Matthew Ward*** (wardm4@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350. *Derived Invariants of Calabi-Yau Threefolds in Positive Characteristic.*

Let X and Y be Calabi-Yau threefolds over a field of positive characteristic. We prove that if $D_{coh}^b(X) \simeq D_{coh}^b(Y)$, then the Artin-Mazur formal groups of X and Y have the same height. We use this to illustrate a derived category approach to the question of when a Calabi-Yau threefold lifts to characteristic 0. (Received July 29, 2012)

1086-14-164 **Martha E Precup*** (mprecup@nd.edu). *Affine pavings of Hessenberg varieties.*

Hessenberg varieties are closed subvarieties of the full flag variety. Examples of Hessenberg varieties include both Springer and flag varieties. We prove that Hessenberg varieties corresponding to nilpotent elements which are regular in a Levi factor are paved by affines. As a consequence, we generalize results of Tymoczko asserting that Hessenberg varieties corresponding to regular nilpotent elements are paved by affines. We then provide a partial reduction from paving Hessenberg varieties for arbitrary elements to paving those corresponding to nilpotent elements, recovering Tymoczko’s result that all Hessenberg varieties corresponding to elements of $\mathfrak{gl}_n(\mathbb{C})$ are paved by affines. (Received August 01, 2012)

1086-14-208 **Danko Adrovic*** (adrovic@math.uic.edu), Dep. of Math., Stat., and Comp. Sci., University of Illinois at Chicago, 322 Science and Engineering Offices (M/C 249), Chicago, IL 60607-7045, and **Jan Verschelde** (jan@math.uic.edu), Dep. of Math., Stat., and Comp. Sci., University of Illinois at Chicago, 322 Science and Engineering Offices (M/C 249), Chicago, IL 60607-7045. *Tropical approach to the cyclic n -roots problem.*

We give a tropical method to address the cyclic n -roots problem. We focus on the case when $n = m^2$ and show how cones of tropisms lead to exact representation of its positive dimensional solution sets. For this specific case, our result offers a tropical version of the lemma of Backelin. (Received August 07, 2012)

1086-14-418 **Pablo Solis*** (pablo@math.berkeley.edu). *A Wonderful Embedding of the Loop Group.*

I describe the wonderful compactification of loop groups. These compactifications are obtained by adding normal-crossing boundary divisors to the group LG of loops in a reductive group G (or more accurately, to the semi-direct product $C^* \times LG$) in a manner equivariant for the left and right $C^* \times LG$ -actions. The analogue for a torus group T is the theory of toric varieties; for an adjoint group G , this is the wonderful compactifications of De Concini and Procesi. The loop group analogue is suggested by work of Faltings in relation to the compactification of moduli of G -bundles over nodal curves. Using the loop analogue one can construct a ‘wonderful’ completion of the moduli stack of G -bundles over nodal curves. (Received August 30, 2012)

- 1086-14-428 **Alexey Ananyevskiy**, , Russia, and **Asher Auel** (asher.ael@gmail.com), **Skip Garibaldi*** (skip@member.ams.org) and **Kirill Zainoulline** (kirill@uottawa.ca), ON , Canada. *Exceptional collections of line bundles on projective homogeneous varieties.*

It has been conjectured that, for every projective homogeneous variety X over the complex numbers, the bounded derived category $D^b(X)$ of coherent sheaves on X contains a full exceptional collection of vector bundles. (This is desirable in the sense that the existence of such a collection gives a way to break up $D^b(X)$ into simple components.) We focus on projective homogeneous varieties under groups of rank at most 2 and settle the question of existence of a full exceptional collection consisting of line bundles. The most difficult case is the variety of Borel subgroups for a group of type G_2 . (Received September 01, 2012)

- 1086-14-438 **Mark E. Huibregtse*** (mhuibreg@skidmore.edu), Dept. of Mathematics and Computer Science, Skidmore College, Saratoga Springs, NY 12866. *Some Elementary Components of the Hilbert Scheme of Points.* Preliminary report.

We present some finite algebras of the form $K[\mathbf{x}]/I$ having “small tangent space” in the sense of Iarrobino and Emsalem [Some Zero-Dimensional Generic Singularities: Finite Algebras Having Small Tangent Space, Compos. Math. 36 (1978), 145–188], where the ideal I is inhomogeneous. For each such I , the corresponding point $[I]$ in the Hilbert scheme of points is a smooth point on an **elementary component** of the Hilbert scheme (that is, a component such that all points on it correspond to closed subschemes of \mathbb{A}_K^n that are concentrated at one point). (Received September 01, 2012)

- 1086-14-451 **Milagros Izquierdo*** (milagros.izquierdo@liu.se), Department of Mathematics, Linköping University, SE-58183 Linköping, Sweden, and **Antonio F Costa** (acosta@mat.uned.es) and **Gabriel Bartolini**. *Automorphisms Groups of Cyclic p-gonal Riemann Surfaces.*

A cyclic p -gonal Riemann surface X is a surface admitting a regular p -sheeted morphism on the projective line, the p -gonal morphism. A Riemann surface is *real* if it admits an anticonformal involution, a symmetry, as an automorphism. Real p -gonal surfaces, with p prime, are defined by equations of the form $y^p = Q(x)$, where $Q(x)$ is a polynomial in x . A surface is real p -gonal if the p -gonal morphism commutes with the symmetry.

We calculate all the automorphisms groups of cyclic p -gonal and real p -gonal Riemann surfaces. This is a generalization of the work of Bujalance et al. for hyperelliptic and trigonal Riemann surfaces (Received September 03, 2012)

- 1086-14-472 **Daniel Erman*** (erman@umich.edu) and **Melanie Matchett Wood**. *Semiample Bertini Theorems over finite fields.*

We prove a semiample generalization of Poonen’s Bertini Theorem over a finite field. The asymptotic probability of smoothness is computed as a product of local probabilities, taken over the fibers of the morphism determined by the relevant divisor. (Received September 04, 2012)

- 1086-14-574 **Robin Hartshorne***, Department of Mathematics, University of California, Berkeley, CA 94720-3840, and **Paolo Lella** and **Enrico Schlesinger**. *Smooth curves specialize to extremal curves.* Preliminary report.

We consider locally Cohen-Macaulay curves, that is, curves without isolated or embedded points, in projective 3-space. We show that any smooth curve belongs to an irreducible flat family containing an extremal curve. Since the extremal curves for a given degree and genus form an irreducible subset of the Hilbert scheme, we conclude that all smooth curves of degree d and genus g belong to the same connected component of the Hilbert scheme of locally Cohen-Macaulay curves. (Received September 07, 2012)

- 1086-14-604 **Mounir Nisse*** (nisse@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368, and **Frank Sottile** (sottile@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *The generalized order map, and k -convexity of the (co)amoeba complement components.*

Amoebas (resp. coamoebas) are the image under the logarithmic (resp. argument) map of algebraic (or analytic) varieties of the complex algebraic torus. they inherit some algebraic, geometric, and topological properties of the variety itself. First, we show a stronger version of Henriques convexity for amoebas and coamoebas, which complete the generalization of the k -convexity of the amoeba complement in higher codimension. Thus if $V \subset (\mathbb{C}^*)^n$ is a k -dimensional algebraic variety with amoeba \mathcal{A} and coamoeba $co\mathcal{A}$, and $\pi \subset \mathbb{R}^n$ (resp. $\tau \subset (S^1)^n$) be a $(n - k)$ -dimensional plane (resp. torus), then we have the following maps

$$\begin{aligned} H_{n-k-1}(\pi \cap (\mathbb{R}^n \setminus \mathcal{A}), \mathbb{Z}) &\rightarrow H_{n-k-1}((\mathbb{R}^n \setminus \mathcal{A}), \mathbb{Z}) \\ H_{n-k-1}(\tau \cap ((S^1)^n \setminus \overline{co\mathcal{A}}), \mathbb{Z}) &\rightarrow H_{n-k-1}(((S^1)^n \setminus \overline{co\mathcal{A}}), \mathbb{Z}) \end{aligned}$$

are injective. Also, we define an order mapping in higher codimension,

$$H_{n-k-1}(\mathbb{R}^n \setminus \mathcal{A}, \mathbb{Z}) \rightarrow H^k((\mathbb{C}^*)^n, \mathbb{Z})$$

which generalize the one already defined in the hypersurface cases. (Received September 08, 2012)

1086-14-606 **Drake M Harmon*** (dharmon2@fau.edu), **Timothy J Ford** and **Djordje N Bulj**.
Generically Trivial Azumaya Algebras on a Rational Surface with a Non-rational Singularity.

Elementary examples are presented of normal algebraic surfaces X with singular points x such that at the local ring $\mathcal{O}_{X,x}$ there exist Azumaya algebras of all orders in the Brauer group that are split by the field of rational functions on X . These algebra classes correspond to elements of torsion in the class group of the henselian local ring $\mathcal{O}_{X,x}^h$. The surfaces X are affine normal rational and the singularities x are non-rational. (Received September 08, 2012)

1086-14-843 **Andrew Obus*** (andrewobus@gmail.com). *The Oort conjecture on lifting covers of curves.* The Oort conjecture states that a curve with a cyclic group of automorphisms can always be lifted from characteristic p to characteristic zero. This conjecture was recently proven by Obus, Pop, and Wewers. We give an overview of the proof, and mention some related problems. (Received September 13, 2012)

1086-14-867 **Dawei Chen***, Department of Mathematics, Boston College, Chestnut Hill, MA 02467.
Linear series on a ribbon.

A ribbon is a double structure on a reduced curve. In this talk we discuss line bundles and their sections on a ribbon from the perspective of Brill-Noether theory. (Received September 14, 2012)

1086-14-900 **Yoav Len*** (yoav.len@yale.edu), 10 Hillhouse Ave., 442 Dunham Lab, New Haven, CT 06511. *The Brill-Noether rank of a tropical curve.*

The Brill-Noether rank of a tropical curve is an invariant analogous to the dimension of the Brill-Noether locus of an algebraic curve. In this talk, I will show that the Brill-Noether rank varies upper semicontinuously in families of tropical curves of a fixed genus and introduce a specialization lemma relating the Brill-Noether rank of a tropical curve with the dimension of the Brill-Noether locus of an algebraic curve. (Received September 22, 2012)

1086-14-950 **Shreeram S. Abhyankar*** (ram@cs.purdue.edu). *Surface Singularities and Jacobian Problems.* Preliminary report.

A bivariate polynomial f gives a map of the complex plane A to the complex line B . Compactifying this we get a pseudomap f' of the projective plane P to the projective line L . This pseudomap f' has a finite number of indeterminacy points at infinity. These points can be resolved by a sequence of quadratic transformations. Thus we obtain a morphism ϕ from a surface S onto L . The surface S consists of the plane A together with a finite number of exceptional curves C_1, \dots, C_r which can be labelled so that ϕ maps C_i onto L for $1 \leq i \leq s$, and it maps C_i onto a single point of L for $s+1 \leq i \leq r$. The curves C_1, \dots, C_s are called the dicritical divisors of f . Let g be another bivariate polynomial. The jacobian problem conjectures that f, g is a jacobian pair iff it is an automorphic pair. It is hoped that comparing the dicritical divisors of f and g will throw some new light on this, so far untractable, conjecture. (Received September 17, 2012)

1086-14-974 **Sebastian Casalaina-Martin***, University of Colorado Boulder, Department of Mathematics, Boulder, CO 80309, and **Jesse Kass** and **Filippo Viviani**. *The local structure of compactified Jacobians.*

The Jacobian of a nonsingular curve is an abelian variety parameterizing degree zero line bundles on the curve. The close connection between the geometry of the curve, and the geometry of the Jacobian has been studied in great depth since the 19th century. For singular curves, the connection between a curve and its Jacobian is still not fully understood. Caporaso, Oda-Seshadri, Pandharipande, and Simpson have constructed spaces called compactified Jacobians, which play the role of the Jacobian in the case of stable curves. I will discuss joint work with J. Kass and F. Viviani, where we describe the singularities of these compactified Jacobians. Time permitting, applications to the geometry of stable curves and moduli spaces will also be discussed. (Received September 17, 2012)

1086-14-980 **Benjamin Antieau*** (antieau@math.ucla.edu) and **Ben Williams** (tbwillia@usc.edu). *Azumaya maximal orders do not always exist.*

I will explain how to use the homotopy theory of classifying spaces of algebraic groups to construct smooth complex varieties X and Brauer classes α over X with the following property: if D is the division algebra over

the function field of X with Brauer class α , then there is no Azumaya algebra on X with class α that restricts to D . In particular, no maximal order over X in D is Azumaya; equivalently, no maximal order over X in D is locally free. (Received September 17, 2012)

1086-14-995 **Douglas A Torrance*** (torrance@vandals.uidaho.edu), Department of Mathematics, University of Idaho, 300 Brink Hall, Moscow, ID 83844. *Nondefective secant varieties of split varieties*. Preliminary report.

Suppose \mathbb{k} is an algebraically closed field and $R = \mathbb{k}[x_0, \dots, x_n]$. For a fixed d , the split variety, or variety of completely decomposable forms, consists of all points in $\mathbb{P}R_d$ which correspond to polynomials that are the product of d linear factors.

For every s distinct points lying on this variety, there is an $(s-1)$ -plane containing them. We define the closure of the union of all these $(s-1)$ -planes as the secant variety. We expect that the secant variety of a split variety will either fill up the projective space or have dimension $s(dn+1)$. In this case, the secant variety is said to be nondefective. Otherwise, it is said to be defective.

It is conjectured that the secant variety to a split variety will be defective if and only if $d = 2$ and $2 \leq s \leq n/2$. It remains to show that the remaining cases are nondefective. We provide a partial proof of this conjecture, for $s \leq 15$. (Received September 17, 2012)

1086-14-1060 **Mark Gross*** (mgross@math.ucsd.edu). *Tropical geometry and cluster algebras*. Preliminary report.

I will give a preliminary report on research currently being conducted with Paul Hacking, Sean Keel, Maxim Kontsevich and others concerning applications of mirror symmetry and tropical geometry to cluster algebras. In particular, we use tropical means to construct canonical bases for cluster algebras. (Received September 18, 2012)

1086-14-1090 **Sean Dodd Lawton*** (lawtonsd@utpa.edu), Department of Mathematics, 1201 W. University Drive, Edinburg, TX 78539, and **Carlos Florentino**. *Topology of Character Varieties of Abelian Groups*. Preliminary report.

Let K be a compact Lie group, G be its complexification, and F be any finitely generated Abelian group. We prove that the conjugation orbit space $\text{Hom}(F, K)/K$ is a strong deformation retract of the GIT conjugation orbit space $\text{Hom}(F, G)/G$. As a corollary, we determine necessary and sufficient conditions for $\text{Hom}(F, G)/G$ to be irreducible when G is connected and semisimple, and F is free Abelian. This is joint work with C. Florentino. (Received September 26, 2012)

1086-14-1108 **Nickolas Hein*** (nhein@math.tamu.edu), Texas A&M University, Department of Mathematics, Mailstop 3368, College Station, TX 77843-3368. *Numerical Methods for Solving Schubert Problems*. Preliminary report.

A complete Schubert problem is given by a system of determinantal equations, which are wildly overdetermined. This aids in Gröbner basis calculations, but encumbers numerical methods. Using duality, I recast the overdetermined system (more equations than variables) as a square system, adding variables but reducing from high-degree determinants to bilinear equations. This often boosts efficiency tremendously.

Numerical methods apply to the new system. Regeneration (solving equation by equation), is valid even for incomplete Schubert problems, i.e. unions of curves, surfaces, etc. This solves Schubert problems which are otherwise infeasible. Parameter homotopy is even faster when it may be used. Both methods parallelize wonderfully.

In this talk I will transform determinantal equations to bilinear equations, we will see the differing strengths of each method, and I will give computational evidence in favor of the new system of equations. (Received September 24, 2012)

1086-14-1135 **Asher Auel*** (auel@cims.nyu.edu), Courant Institute of Mathematical Sciences, New York University, **R. Parimala** (parimala@mathcs.emory.edu), Department of Mathematics & CS, Emory University, and **V. Suresh** (suresh@mathcs.emory.edu), Department of Mathematics & CS, Emory University. *Quadric surface bundles and quaternion algebras*.

We study quadric surface bundles $X \rightarrow S$, i.e., families of quadric surfaces parameterized by S and degenerating to cones along a divisor $D \subset S$. We show that when S is a regular surface, quadric surface bundles are classified by quaternion Azumaya algebras over a double cover $T \rightarrow S$ branched along the degeneration divisor D . Among the many arithmetic and geometric applications of this result, in this talk we will highlight: constructing counterexamples to the local-global principle for zeros of quadratic forms over function fields of surfaces, and the geometry of cubic fourfolds containing a plane. (Received September 19, 2012)

1086-14-1177 **Yi Zhu*** (yzhu@math.utah.edu), Department of Mathematics, University of Utah, Salt Lake City, UT 84112. *Homogeneous Spaces over Function Fields of Dimension Two.*

Let K be either a global function field or a function field of an algebraic surface. Johan de Jong formulated the following principle: a “rationally simply connected” K -variety admits a rational point if and only if the elementary obstruction vanishes. In this talk, I will discuss how this principle works for projective homogeneous spaces. In particular, it leads to a classification-free result towards the quasi-split case of Serre’s Conjecture II over K . (Received September 20, 2012)

1086-14-1188 **Lawrence Ein, Robert Lazarsfeld and Yusuf Mustopa*** (mustopa@bc.edu). *Stability of Syzygy Bundles.*

The syzygy bundle associated to a subvariety $X \subseteq \mathbb{P}^n$ governs the fine structure of the equations which cut out X in \mathbb{P}^n . A classical result of Ein-Lazarsfeld implies that this bundle is stable when X is a smooth curve embedded in \mathbb{P}^n by a complete linear series of large degree. In this talk I will discuss joint work with Lawrence Ein and Rob Lazarsfeld which attempts to generalize this to varieties of higher dimension. (Received September 19, 2012)

1086-14-1223 **Guido Pezzini*** (pezzini@math.fau.de), Department Mathematik, Universität Erlangen-Nürnberg, Cauerstraße 11, 91058 Erlangen, Germany. *On reductive automorphism groups of regular embeddings.*

In the 70’s Demazure determined the connected automorphism groups of two distinguished classes of complex algebraic varieties equipped with the action of a connected reductive algebraic group G . They were the complete homogeneous spaces, i.e. the quotients G/P with P a parabolic subgroup of G , and the toric varieties (assuming G is abelian).

These results admit a common generalization to a certain class of smooth complete G -varieties, called regular embeddings. They have been studied by several mathematicians such as Bifet, De Concini, Procesi, Bien, Brion, and play a significative role in the theory of spherical varieties.

In the talk we will discuss this generalization, and as a byproduct how it is possible to describe combinatorially all orbits of a toric variety under the action of a Levi subgroup of its connected automorphism group. (Received September 20, 2012)

1086-14-1232 **Kefeng Liu, Feng Guan and Xiaojing Chen*** (sherrychen42@gmail.com), 1762 Malcohm Ave, Los Angeles, CA 90024. *Global Torelli Theorem For Projective Manifolds Of Calabi-Yau Type.*

We prove two main results about the global properties of the period maps from the Teichmüller space of polarized and marked Calabi-Yau type manifolds to the period domain of polarized Hodge structures. (Received September 20, 2012)

1086-14-1305 **Laurentiu G Maxim*** (maxim@math.wisc.edu), Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706. *Characteristic numbers of singular complex varieties.*

I will survey various constructions and properties of genera and characteristic numbers of singular complex algebraic varieties. In particular, I will discuss genera for the singular varieties appearing in the minimal model program, as well as those defined by Hodge theory and functorial characteristic classes. (Received September 21, 2012)

1086-14-1313 **Joshua T. Wood*** (wood7991@gmail.com). *Krichever Dynamics on a Ruled Surface.* Preliminary report.

The (1 dimensional) Krichever construction takes as inputs a curve, a point on the curve, a line bundle trivialized at the point, and some additional data. Out of this data one gets solutions of nonlinear pde’s (such as the KdV equation) in one space variable by flowing linearly in the Jacobian. Rothstein generalized this construction to higher dimensional varieties, and proved an analogous existence theorem for (matrix valued) pde’s in several space variables. I will discuss current work and results from specializing to the case where the variety is a ruled surface. (Received September 21, 2012)

1086-14-1335 **Caroline Junkins*** (cjunk084@uottawa.ca). *Estimating torsion using the twisted gamma-filtration.*

For the Grothendieck group of a split simple linear algebraic group, the twisted γ -filtration provides a useful tool for constructing torsion elements in γ -rings of twisted flag varieties. In the present talk, we construct a non-trivial torsion element in the γ -ring of a complete flag variety twisted by means of a PGO -torsor. This generalizes the construction in the $HSpin$ case previously obtained by Zainoulline. (Received September 21, 2012)

- 1086-14-1460 **Jeff A Rosoff*** (jr@gac.edu), Dept. of Mathematics and Computer Science, Gustavus Adolphus College, St. Peter, MN 56082. *The Monoid of Effective Divisor Classes on an Algebraic Surface.*

The Neron-Severi group $NS(X)$ of divisor classes modulo algebraic equivalence on an algebraic surface X is often not difficult to calculate; it is always finitely generated and its rank is an important invariant of X . Contained in this group is the monoid $M(X)$ consisting of those classes represented by an effective divisor; $M(X)$ is harder to calculate than $NS(X)$ and need not be finitely generated.

In this talk we will examine cases in which $M(X)$ is finitely generated, and cases in which finite generation fails. We will see that the techniques of determining this depend heavily on the surface type of X . In the case of finite generation we will illustrate minimal generating sets of effective divisor classes. (Received September 22, 2012)

- 1086-14-1547 **June Huh*** (junehuh@umich.edu). *The tropical Laplacian.*

The tropical Laplacian is a symmetric square matrix associated to a tropical surface, defined in a similar way to the Laplacian of a graph. In this joint work with Eric Katz, we show that the tropical Laplacian provides a new necessary condition for the realizability of a tropical surface. (Received September 23, 2012)

- 1086-14-1574 **Guido Pezzini**, Cauerstr. 11, 91058 Erlangen, Germany, and **Bart Van Steirteghem***, 1650 Bedford Avenue, Brooklyn, NY 11225. *On the weight monoids of smooth affine spherical varieties.*

Spherical varieties form a remarkable class of algebraic varieties equipped with an action of a complex reductive group G . They include toric, flag and symmetric varieties. A natural invariant of an affine spherical variety X is its weight monoid $\Gamma(X)$. It is the set of irreducible representations of G occurring in the coordinate ring of X , which is a multiplicity free G -module. In the 1990s, F. Knop conjectured that it is a complete invariant for smooth affine spherical varieties, and in 2006 I. Losev proved this conjecture. Little is known about the image of the map that sends a smooth affine spherical variety to its weight monoid. We combinatorially characterize those free and “ G -saturated” monoids that belong to this image. (Received September 23, 2012)

- 1086-14-1673 **Ivona Grzegorczyk*** (ivona.grze@csuci.edu), Dept. of Mathematics, California State University Channel Islands, One University Drive, Camarillo, CA 93012. *Vector bundles with sections on algebraic curves.* Preliminary report.

We study moduli spaces of stable vector bundles on smooth algebraic curves. We will report on the current state of the Brill-Noether problem, including new examples for bundles of $\text{rk} = 2$. We will show new results for calculating dimensions of moduli spaces of stable bundles with fixed determinants, or more general for certain coherent systems. (Received September 24, 2012)

- 1086-14-1695 **Frank Sottile*** (sottile@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368, and **Tina Mai** (mai@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *The convex hull of a pair of circles.* Preliminary report.

We describe the boundaries of the convex hulls of perhaps the simplest compact curves in three-dimensional space, pairs of circles. This convex hull consists of a 1-dimensional family of line segments (called the edge surface) and one or two discs. This edge surface is in general an irrational ruled surface whose rulings form a $(2, 2)$ -curve in the product of the circles. We classify which real $(2, 2)$ -curves arise, and use this to classify the convex hulls. (Received September 24, 2012)

- 1086-14-1751 **Jihyeon Jessie Yang*** (jyang@math.mcmaster.ca). *Tropical Severi Varieties and Applications.*

We study the tropicalizations of Severi varieties, which we call tropical Severi varieties. Severi varieties are classical objects in algebraic geometry. They are parameter spaces of plane nodal curves. On the other hand, tropicalization is an operation in tropical geometry, which turns subvarieties of an algebraic torus into polyhedral objects in a real vector space. By studying the tropicalizations, it may be possible to transform algebro-geometric problems into combinatorial ones.

We find a partial description of tropical Severi varieties in terms of subdivisions of polygons. Given a subdivision of a polygon, we construct another parameter space. This space is a much simpler object than the given Severi variety and it describes the tropical Severi variety.

We present two applications. First, we understand G. Mikhalkin’s correspondence theorem in terms of tropical intersection theory. In particular, this provides a proof of the independence of point configurations in the enumeration of tropical nodal curves. The second application is about Secondary fans. Secondary fans are

purely combinatorial objects which parameterize the regular subdivisions of marked polygons. We provide a relation between tropical Severi varieties and Secondary fans. (Received September 24, 2012)

1086-14-1757 **SWARNA MUKHOPADHYAY*** (swarnava@live.unc.edu). *Rank-level duality for odd orthogonal Lie algebras.*

Classical invariants for representations of one Lie group can often be related to invariants of some other Lie group. Physics suggests that the right objects to consider for these questions are certain refinements of classical invariants known as conformal blocks. Conformal blocks appear in algebraic geometry as spaces of global sections of line bundles on the moduli stack of parabolic bundles on a smooth curve. Rank-level duality connects a conformal block associated to one Lie algebra to a conformal block for a different Lie algebra. In this paper we prove a rank-level duality for type $\mathfrak{so}(2n+1)$ on the pointed projective line conjectured by T. Nakanishi and A. Tsuchiya. (Received September 24, 2012)

1086-14-1758 **Chris Peterson*** (peterson@math.colostate.edu). *Special sections of locally free sheaves.* Let \mathcal{E} be a rank r locally free sheaf on \mathbb{P}^n with $r \leq n$. Assuming \mathcal{E} is globally generated, the vanishing locus of a general section of \mathcal{E} will be a smooth variety of codimension r . A section of \mathcal{E} is called special if its vanishing locus fails to be smooth and/or fails to have the expected codimension. This talk will discuss three examples involving special sections with emphasis placed on the related geometry. (Received September 24, 2012)

1086-14-1767 **Anthony Várilly-Alvarado and Bianca Viray*** (bviray@math.brown.edu). *Vertical Brauer groups and degree 4 del Pezzo surfaces.*

We show that Brauer classes of a locally solvable degree 4 del Pezzo surface X are vertical, that is, that every Brauer class is obtained by pullback from an element of $\mathrm{Br} k(\mathbb{P}^1)$ for some rational map $f: X \dashrightarrow \mathbb{P}^1$. As a consequence, we prove that a Brauer class does not obstruct the existence of a rational point if and only if there exists a fiber of f that is locally solvable. The proof is constructive and gives a simple and practical algorithm, distinct from that in [BBFL07], for computing all nonconstant classes in the Brauer group of X . (Received September 24, 2012)

1086-14-1780 **Sema Gunturkun*** (gunturkun@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40508, and **Uwe Nagel**. *A Construction of Homogeneous Gorenstein Ideals.* Preliminary report.

In 1983 Kustin and Miller introduced a construction of Gorenstein ideals in local rings. We review their construction in the case of graded rings and modify it by avoiding ring extensions. We also discuss this construction with respect to liaison theory. (Received September 25, 2012)

1086-14-1800 **Dagan Karp*** (dkarp@hmc.edu). *Toric Symmetry in Gromov-Witten Theory.*

Gromov-Witten invariants are functorial under isomorphism; hence any automorphism which acts nontrivially on cohomology lifts to a nontrivial identity in GW theory. Toric symmetries are a particularly rich class of automorphism. We will discuss toric symmetry in GW theory in several explicit examples, and present enumerative interpretations. Portions of this work are joint with Dhruv Ranganathan and Amin Gholampour. (Received September 24, 2012)

1086-14-1803 **Craig Costello***, Microsoft Research, One Microsoft Way, Redmond, WA 98052. *Efficient arithmetic on Jacobians of genus 2 curves.* Preliminary report.

This talk will survey the fastest methods of arithmetic on Jacobians of genus 2 curves. In particular, an especially attractive Kummer surface associated to such Jacobians was shown by Gaudry (in 2007) to facilitate much faster arithmetic than on the Jacobian itself. The transformation of the genus 2 curve to this Kummer surface is usually achieved via the Rosenhain invariants. Using these invariants imposes some restrictions on the type of curve one can use, namely that the two torsion must be defined over the ground field. Through the use of analytic theory, we bypass the use of the Rosenhain invariants to (in certain cases) ease this restriction, which allows a wider range of curves to take advantage of the state-of-the-art in fast genus 2 arithmetic. (Received September 24, 2012)

1086-14-1819 **Ariel Setniker*** (asetniker09@wou.edu) and **Melissa Haire** (melissa.haire@gordon.edu). *The Complement of Fermat Curves in the Plane.*

A plane algebraic curve is a curve defined implicitly by a relation of the form $f(x, y) = 0$, where $f(x, y)$ is a polynomial in x and y . A curve is said to be rational if it can be parametrized by rational functions $x(t), y(t)$. In this talk we will discuss necessary conditions for a rational curve to be defined on the complement of high degree algebraic Fermat curves. (Received September 24, 2012)

1086-14-1833 **Amy Ksir*** (ksir@usna.edu) and **Caroline Grant Melles** (cgg@usna.edu).
Automorphisms of algebraic, tropical, and non-Archimedean analytic curves.

Let K be an algebraically closed field, complete with respect to a nontrivial non-Archimedean absolute value. For a smooth algebraic curve X over K , there is an associated Berkovich analytic curve X_{an} . One can choose a semistable vertex set, which is a finite set of points of X_{an} , and define the associated skeleton $\Sigma(X, V)$ of X , which is a finite metric graph embedded in X_{an} . Different tropicalizations of X are induced by different toric embeddings. Baker, Payne and Rabinoff showed that for each tropicalization X_{trop} of X , there is a natural map from X_{an} to X_{trop} that factors through a retraction onto a skeleton $\Sigma(X, V)$.

We will describe some of the relationships between the automorphism groups of X , X_{an} , $\Sigma(X, V)$, and X_{trop} . Many pictures and interesting examples will be given. (Received September 24, 2012)

1086-14-1852 **Sam Payne***, Yale University, New Haven, CT. *Topology of nonarchimedean analytic spaces.*

The usual norm on the complex numbers and its associated analytic geometry (holomorphic functions and differential forms) have been fundamental tools for understanding the geometry and topology of complex algebraic varieties since the beginnings of the subject. Nonarchimedean norms, such as the p -adic norm on the rational numbers, also have an associated analytic geometry, which has been used extensively in number theory, but is just beginning to be applied in other areas of mathematics, such as algebraic geometry and dynamics. Even the most basic topological properties of nonarchimedean analytic spaces can be quite subtle. For instance, it was only in 2010 that Hrushoski and Loeser proved that the nonarchimedean analytification of an algebraic variety, in the sense of Berkovich, is locally contractible and has the homotopy type of a finite simplicial complex.

This talk will introduce the basics of nonarchimedean geometry and survey recent developments in the topology of nonarchimedean analytic spaces, highlighting relations to tropical geometry, invariants of singularities, birational geometry, and mixed Hodge theory. (Received September 24, 2012)

1086-14-1866 **Yang Qi*** (yangqi@math.tamu.edu), 200 Charles Haltom Avenue Apt. 4-D, College Station, TX 77840. *On the equations of the third secant variety of an n -fold Segre product.*

It is well known that the third secant variety of a triple Segre product is defined by the size four minors of flattenings and Strassen's equations. In this talk we are going to give this result a new proof, which can be generalized to the n -factor case. Then we can have the set theoretically defining equations of the third secant variety of an n -fold Segre product. (Received September 24, 2012)

1086-14-1915 **Tyler Foster, Philipp Gross and Sam Payne*** (sam.payne@yale.edu). *Limits of tropicalizations.*

I will discuss joint work with Tyler Foster and Philipp Gross, realizing nonarchimedean analytifications of arbitrary closed subschemes of toric varieties as limits of tropicalizations of toric embeddings. This generalizes earlier results for quasiprojective varieties. (Received September 24, 2012)

1086-14-1918 **Luke Oeding*** (oeding@math.berkeley.edu), Department of Mathematics, 970 Evans Hall, Berkeley, CA 94720, and **Giorgio Ottaviani**. *Eigenvectors of tensors and algorithms for Waring decomposition.*

A polynomial is said to have rank r if it can be written as a sum of r powers of linear forms. Waring's problem is to find this decomposition. While a naive algorithm exists, it is unlikely to succeed even in modest examples. One goal is to provide algorithms which succeed to decompose polynomials of low rank as quickly as possible. With Ottaviani we have developed new algorithms for Waring decomposition, which generalize Sylvester's algorithm for binary forms, using vector bundle techniques together with the notion of an eigenvector of a tensor. Despite their perhaps sophisticated appearance, our algorithms mainly consist of computations involving linear algebra and succeed to quickly decompose polynomials in a larger range of ranks than was previously available. I will explain these algorithms from the level of linear algebra and show their implementation in Macaulay 2. (Received September 24, 2012)

1086-14-2037 **Hilaf Hasson*** (hxx37@psu.edu). *Fields of Definition of G -Galois Branched Covers of the Projective Line.*

Riemann's Existence Theorem implies that for every finite group G there is a G -Galois branched cover of the projective line over $\bar{\mathbb{Q}}$. Hilbert's Irreducibility Theorem implies that if such a cover descends to a number field K , then G is realizable as a Galois group over K . Therefore understanding descent of G -Galois branched covers is relevant to the Inverse Galois Problem. I will discuss some results about the structure of the fields of definition of these covers, and briefly describe what goes into these results. (Received September 24, 2012)

1086-14-2055 **Kristin Lauter*** (klauter@microsoft.com), **Michael Naehrig** and **Tonghai Yang**. *A smaller set of invariants for genus 2 curves*. Preliminary report.

Constructing genus 2 curves using their modular invariants is a computationally intensive task. Until recently, the modular invariants used were the “Igusa invariants”, CM values of 3 Siegel modular forms on the Siegel moduli space. Recent work showed that the curves could in fact be constructed from 2 modular invariants on the Hilbert moduli space, the “Gundlach invariants”, where the modular functions are functions of 2 variables instead of 3, and the CM points are easier to describe. In this work, we show how to express these new invariants in terms of theta functions for efficient computation, and analyze the comparative running times of different approaches to computing these invariants. (Received September 24, 2012)

1086-14-2092 **Jeremy B. Jankans*** (jjankans@math.uci.edu), 440T Rowland Hall, Irvine, CA 92697. *Algebraic Cylces, Chow Varieties, and Symmetric Polynomials*. Preliminary report.

We want to understand spaces that parameterize projective subvarieties. One way to do this is to look at Algebraic Cycles. An Algebraic Cycle is a formal sum

$$\sum c_i X^i,$$

where $X^i \subset \mathbb{P}^{n-1}$ is an irreducible closed subvariety. If we take a family of irreducible subvarieties, its limit may have several irreducible components, i.e. the limit may be a general cycle.

We want to study this phenomenon and the Chow Varieties are a way of doing thins. Simply put, the points of a Chow variety are Algebraic Cycles. We will explain at the Chow - Van der Waerden Theorem that imbeds the variety into projective space.

Finally we move on to a specific example, 0-cycles. We can use symmetric polynomials to work with 0-cycles. Using this we will look at the tangent space, and derive a formula for the tangent space of a multiple of smooth point. (Received September 25, 2012)

1086-14-2158 **Danko Adrovic*** (adrovic@math.uic.edu), Department of Math., Stat., and Comp. Sci., 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60607-7045, and **Jan Verschelde** (jan@math.uic.edu), Department of Math., Stat., and Comp. Sci., 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60607-7045. *Puiseux Series Expansions for Algebraic Sets*.

We give a polyhedral method to develop Puiseux series expansions for algebraic sets. We begin the development of the Puiseux series expansion by computing cones of pretropisms. The cones of pretropisms are the common cones of normal vectors to the Newton polytopes, corresponding to the polynomials in the system, which defines the algebraic set. The cones of pretropisms lead to initial form systems, whose isolated solutions in $(\mathbb{C}^*)^n$ correspond to the leading coefficients in the Puiseux series expansion of the algebraic set. Furthermore, the pretropisms in the cone are identified as leading exponents in the Puiseux series and the dimension of the cone as the dimension the algebraic set. Cones of pretropisms, which lead to a Puiseux series, are called tropisms. Our polyhedral method takes advantage of symmetry, which reduces the computational time significantly and it allows us to gain additional insights into the nature of the algebraic sets that are being developed. For example, the application of our polyhedral method to the cyclic n -roots problem lead to the exact representation of the solutions sets for $n = m^2$, leading to a tropical perspective on the lemma of Backelin. (Received September 24, 2012)

1086-14-2163 **Evgeny Mayanskiy*** (esm155@psu.edu), 411 Waupelani Drive, Apt C-033, State College, PA 16801. *Endomorphism algebras of Kuga-Satake varieties*.

We compute the endomorphism algebra of a Kuga-Satake variety. (Received September 24, 2012)

1086-14-2212 **Jia Wan*** (wan2235@vandals.uidaho.edu), 1218 S.Main #602, Moscow, ID 83843. *On the Secant Defectivity and the Waring's Problems*.

Consider an irreducible, non-degenerate projective variety X . The k -th secant variety of X is the Zariski closure of the union of the linear spaces spanned by collections of k linearly independent points on X . One study of this object is centered around finding its dimension. Recently, scientists have shown more interest in this topic since the problem is strongly connected to questions in representation theory, coding theory, and combinatorics. In 1995, work by J. Alexander and A. Hirschowitz completed a project that was underway for over 100 years and confirmed the conjecture that finished the Waring's problem for forms. However, the problem is still unsolved in its generality. In this talk, I will explain techniques involved in classifying defective secant varieties of some classically studied varieties, its relation with generalized Waring's problems, as well as conjectures, open problems and some recent improvements we have achieved in this area. (Received September 25, 2012)

1086-14-2232 **Lance Gurney*** (lance.gurney@anu.edu.au). *Lambda structures on stacks.*

For a flat scheme to have a Lambda structure is to ask that it have a commuting family of Frobenius lifts. I'll discuss what it means for a stack to have a Lambda structure and then describe the simple, though still interesting, example of the Lambda structure on the moduli stack of elliptic curves with complex multiplication. Finally, I'll make some remarks on how the Lambda structure on this stack relates to some aspects of elliptic curves with complex multiplication (in particular when they admit Lambda structures and to a certain type of "canonical lift" for such curves). (Received September 25, 2012)

1086-14-2294 **Chitrabhanu Chaudhuri*** (chitro@u.northwestern.edu), 2033 Sheridan Road, Department of Mathematics, Northwestern University, Evanston, IL 60208. *Affine Stratification Number and Compactified Moduli Space of Curves.*

An affine stratification of a variety is like a cellular complex except built up by affine varieties which are locally closed. I shall explain the topological consequences of affine stratifications.

The affine stratification number of M_g , the moduli space of curves of genus g is $g - 2$ for $g \leq 5$. Let \overline{M}_g be the Deligne-Mumford compactification. We explore a natural filtration on $\overline{M}_g = \bigcup_k M_g^k$, and the corresponding stratification on $\overline{H}_g = \bigcup_k H_g^k$, the hyper-elliptic locus. I shall talk about affine stratification of H_g^k .

To obtain a sharp result we shall have to do some cohomology computations and that is where colored operads, and McDonald's symmetric functions are used. (Received September 25, 2012)

1086-14-2387 **Dustin Cartwright***, dustin.cartwright@yale.edu. *Tropical complexes.* Preliminary report.

A tropical complex is a Δ -complex together with some additional data, which can be obtained from a sufficiently nice subdivision of a tropical variety. Tropical complexes are one possible generalization of graphs to higher dimensions in tropical geometry. I will introduce tropical complexes and talk about some of the analogues that can be developed with algebraic surfaces and higher dimensional varieties. (Received September 25, 2012)

1086-14-2591 **Joseph A Ross*** (josephr@usc.edu). *Cohomology Theories with Supports.*

For a cohomology theory E defined on the category of smooth schemes over a field (for example, algebraic K -theory), we prove a duality theorem relating E -cohomology to E -homology of a scheme that is either affine or projective. The techniques are geometric in nature, the main tool being a moving lemma. We will spend some time discussing a broader context for the problem before sketching the proof. (Received September 25, 2012)

1086-14-2605 **Peter Buser*** (peter.buser@epfl.ch), Section de Mathématiques, SB MATHGEOM, Station 8, CH-1015 Lausanne, Switzerland, and **Eran Makover**, **Bjoern Muetzel** and **Robert Silhol**. *Jacobians of limit Riemann surfaces and Kirchhoff's rules.*

Consider a family of compact Riemann surfaces given by Fenchel-Nielsen parameters, where k of the length parameters go to zero and all other parameters are kept fixed. The Jacobians then tend to the Jacobian of the limit surface. In the lecture we show that this gives rise to a concept of Jacobians for finite graphs which should allow one to investigate certain phenomena in a simple computational setting. The Jacobians proposed here have twice the expected dimension and obey the Kirchhoff rules of electric circuits. (Received September 25, 2012)

1086-14-2687 **Jaeho Shin*** (jshin@math.uga.edu), University of Georgia, Department of Mathematics, DW Brooks Drive, Athens, GA 30602. *The Reduction Map for the Moduli Spaces of Weighted Stable Hyperplane Arrangements.* Preliminary report.

Alexeev constructed moduli spaces of weighted stable hyperplane arrangements generalizing the Hassett's moduli space of curves of genus 0 with weighted n points. For curves, the reduction map $\overline{\mathcal{M}}_{(1,1,\dots,1)}(2,n) \rightarrow \overline{\mathcal{M}}_{(b_1,b_2,\dots,b_n)}(2,n)$ is surjective for any weight (b_1,b_2,\dots,b_n) . We prove that for surfaces, the reduction map is surjective when $n = 5, 6, 7, 8$ and there is a counterexample when $n \geq 9$. (Received September 25, 2012)

1086-14-2709 **Sarah E. Anderson***, sarah5@g.clemson.edu, and **Gretchen L. Matthews**. *Rates of polarization of polar codes constructed using algebraic geometry code kernels.*

In recent groundbreaking work, Arikan developed polar codes as an explicit construction of symmetric capacity achieving codes for binary DMCs with low encoding and decoding complexity. In this construction, a kernel matrix

$$G = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$$

is considered, and $G^{\otimes n}$ is used to encode a block of 2^n channels. As the number of channels grows, each channel becomes either a noiseless channel or a pure-noise channel, and the rate of this *polarization* is related to the

kernel matrix used. Since Arikan's original construction, polar codes have been expanded to q -ary DMCs, where q is a power of a prime, and other matrices besides G have been considered as kernels. Algebraic geometry code kernels were first considered by Mori and Tanaka and Korada and Şaşoğlu using Reed-Solomon and BCH codes as kernels. In our work, we implement more general constructions with algebraic geometry codes as kernels. While Mori and Tanaka showed Reed-Solomon kernels give the best possible exponent for kernels of size $l \leq q$, we show that considering larger matrices from algebraic geometry codes over \mathbb{F}_q yields better exponents meaning better rates of polarization. (Received September 25, 2012)

1086-14-2721 **Michael P Kasa*** (michael.p.kasa@gmail.com), 4066 Albatross St, Apt 26, San Diego, CA 92103. *Gromov-Witten invariants for relatively coherent log schemes*. Preliminary report.

A theory of Gromov-Witten invariants has been developed by M. Gross and B. Siebert for special cases of fine saturated log schemes. Our goal is to extend this theory to include relatively coherent log schemes. Such log structures are naturally occurring, for example, as divisorial log structures on singular schemes. (Received September 25, 2012)

1086-14-2725 **Xia Liao*** (xliao@math.fsu.edu), Department of Mathematics, Florida State University, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306. *Chern classes of logarithmic vector fields for locally quasi-homogeneous free divisors*.

Let X be a nonsingular complex projective variety and D a locally quasi-homogeneous free divisor in X . In this presentation we report a numerical relation between the Chern class of the sheaf of logarithmic derivations on X with respect to D , and the Chern-Schwartz-MacPherson class of the complement of D in X . Our result confirms a conjectural formula for these classes, at least after push-forward to projective space; it proves the full form of the conjecture for locally quasi-homogeneous free divisors in \mathbb{P}^n . The result generalizes several previously known results. For example, it recovers a formula of M. Mustata and H. Schenck for Chern classes for free hyperplane arrangements. Our main tools are Riemann-Roch and the logarithmic comparison theorem of Calderon-Moreno, Castro-Jimenez, Narvaez-Macarro, and David Mond. As a subproduct of the main argument, we also obtain a schematic Bertini statement for locally quasi-homogeneous divisors. <http://arxiv.org/abs/1205.3843> (Received September 25, 2012)

1086-14-2824 **Jeremy Pecharich*** (jpechari@tholyoke.edu), 50 College Street, South Hadley, MA 01075. *Derived Symplectic Resolutions*.

Symplectic resolutions have become an integral part of representation theory with applications to symplectic reflection algebras, nilpotent orbits, and the $n!$ -conjecture. Unfortunately, symplectic resolutions rarely exist! For example, a theorem of Misha Verbitsky states that if the quotient space V/G of a symplectic vector space by a finite group G has a symplectic resolution then G is generated by symplectic reflections and there are explicit counterexamples to show that the converse cannot hold. However, using the more flexible language of derived symplectic geometry due to T. Pantev, B. Toen, M. Vaquie, and G. Vezzosi we will provide a construction of a derived symplectic resolution for quotients V/G for V a symplectic vector space and G any finite subgroup in $Sp(V)$. With time permitting we will state a conjectural extension of the symplectic McKay correspondence of R. Bezrukavnikov and D. Kaledin to the derived symplectic setting. (Received September 25, 2012)

1086-14-2831 **Michel van Garrel***, MC 253-37, 1200 E California Blvd, Pasadena, CA 91125. *Rationality of some homogeneous spaces*.

In this talk, we describe an explicit birational isomorphism from a special type of torus to a projective space. This generalizes a result by Klyachko that proves a special case of a conjecture of Voskresenskii.

More precisely, a variety X over a field k is said to be stably rational if $X \times_k \mathbb{P}_k^m$ is rational for some $m \geq 0$. The above mentioned conjecture of Voskresenskii states that a stably rational torus over k should be rational. This is widely open. A result of Klyachko gives a positive answer for a certain type of stably rational tori, given by the quotient of $(A \otimes_k B)^*$ by the subgroup generated by A^* and B^* . Here A and B are étale k -algebras of coprime dimension over k .

In our work, we generalize the situation to the case where A and B are *any* finite-dimensional k -algebras of coprime dimension over k . Note that in this case, the quotient is not necessarily a torus anymore. It need not even be an algebraic group. However, we show that it is a rational variety by providing a simple explicit birational isomorphism to a projective space. This is joint work with Mathieu Florence. (Received September 25, 2012)

1086-14-2852 **Julianna Tymoczko*** (jtymoczko@smith.edu), Clark Science Center, Smith College, Northampton, MA 01063. *Springer varieties, Hessenberg varieties, and poset pinball.*

We discuss poset pinball, a combinatorial method for computing the (equivariant) cohomology of certain algebraic varieties. Poset pinball can be applied to varieties like Springer varieties and Hessenberg varieties, whose cohomology often carries interesting representations. We describe what is known about these representations, as well as what is conjectured. (Received September 25, 2012)

1086-14-2930 **Eric Edward Katz*** (eekatz@math.uwaterloo.ca), Department of C & O, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada. *Geometric rank functions and rational points on curves.*

The Chabauty-Coleman method in number theory gives a method for bounding the number of rational points on particular algebraic curves. We discuss how to use an extension of the rank function of Baker-Norine for linear systems on graphs to improve the bounds for curves with bad reduction. This is joint work with David Zureick-Brown. (Received September 26, 2012)

1086-14-2944 **Korben Allen Rusek*** (krusek@math.tamu.edu), Texas A&M, Math Dept MS 3368, College Station, TX 77843. *Non-Archimedean Tropical Discriminants.*

We study A -discriminants from a non-Archimedean point of view, refining earlier work on the tropical discriminant. In particular, we study the case where A is a collection of $n + m + 1$ points in Z^n in general position. For general m , we bound the number of connected components of the complement of the amoeba closure. For fixed m , this bound is polynomial in n , whereas obvious bounds from Kapranov's non-Archimedean theorem are exponential in n . (Received September 26, 2012)

1086-14-2997 **Dhruv Ranganathan** (dhruv.ranganathan@yale.edu). *Gromov-Witten Theory of Blowups of Toric Threefolds*

I will report on joint work with Dagan Karp. We use toric symmetries to study the relationship between the Gromov-Witten theories of $\mathbb{P}^1 \times \mathbb{P}^1 \times \mathbb{P}^1$ and \mathbb{P}^3 . The toric blowup of $\mathbb{P}^1 \times \mathbb{P}^1 \times \mathbb{P}^1$ at two points and six lines is isomorphic to the toric blowup of \mathbb{P}^3 at four points and six lines; this is the permutohedral variety. Gromov-Witten invariants of non-exceptional classes on this variety are equal to certain invariants of $\mathbb{P}^1 \times \mathbb{P}^1 \times \mathbb{P}^1$ and \mathbb{P}^3 . In this talk, I hope to give a friendly introduction to the central ideas in this project. (Received October 02, 2012)

15 ► Linear and multilinear algebra; matrix theory

1086-15-44 **Sarah K. Weissberger*** (weissbsk@dukes.jmu.edu), **Jacob J. Rhodes** and **Carla D. Martin**. *A Multilinear Algebra Approach to Facial Recognition*. Preliminary report.

Multilinear algebra techniques involving tensors have gained recent popularity due to an increase in computational power and required analyses of multidimensional data. In the field of imaging, it has been shown that better results are achieved when data is treated as a tensor, or multiway array, block of data as opposed to matrix slices. In this talk, we utilize a multilinear algebra factorization of tensors that is an extension of the matrix singular value decomposition (SVD) in the context of facial recognition. The tensor singular value decomposition (TSVD), developed in 2011 by Kilmer and Martin, is used to extend the well-known Eigenfaces algorithm to tensors. The advantage of our new method is that images are not vectorized and therefore we take advantage of the inherent structure within the image. We also include a possible application of 3D image recognition that can also be done using this TSVD. (Received June 20, 2012)

1086-15-139 **Eric M Evert*** (evert@vt.edu), **Kileen A Berry** (kylie.berry@vikings.berry.edu) and **Son T Nghiem** (nghiems@bera.edu). *Factor Posets and Dual Frames*. Preliminary report.

A frame in \mathbb{R}^n is a redundant spanning set. Equivalently, a frame is a sequence of vectors $\{f_i\}_{i=1}^k$ for which there exist constants $0 < A \leq B < \infty$ such that, for every x in \mathbb{R}^n , $A\|x\|^2 \leq \sum_{i=1}^k |\langle x, f_i \rangle|^2 \leq B\|x\|^2$. A frame is tight if $A = B$. We will present results about the combinatorial structure of tight frames using factor posets. A factor poset of a frame is defined to be a collection of subsets of I , the index set of our vectors, ordered by inclusion so that nonempty $J \subseteq I$ is in the factor poset if and only if $\{f_i\}_{i \in J}$ is a tight frame in \mathbb{R}^n . We will then discuss some results on dual frames. A set of vectors $\{g_i\}_{i=1}^k$ is said to be a dual frame if for a frame $\{f_i\}_{i=1}^k$ we have that $x = \sum_{i=1}^k \langle x, g_i \rangle f_i$, $\forall x \in \mathbb{R}^n$. We will relate the two topics by discussing the connections between the factor posets of frames and their duals. Additionally we will discuss duals with regard to ℓ^p minimization.

Finally, we extend the notion of diagram vectors for frames in infinite dimensions. The diagram vectors of a frame are used to determine if any given subframe of the frame is tight. (Received July 27, 2012)

1086-15-660 **Daeshik Choi*** (ds77choi@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195. *A proof of Crouzeix's conjecture for a class of matrices.*

Crouzeix's conjecture is that for any square matrix A and any polynomial p we have

$$\|p(A)\| \leq 2 \max\{|p(z)| : z \in W(A)\},$$

where $W(A)$ is the field of values of A and $\|\cdot\|$ denotes the spectral norm. In this paper, we show that the conjecture holds for the matrices of the form

$$\begin{pmatrix} \lambda & \alpha_1 & & & \\ & \ddots & \ddots & & \\ & & \ddots & \ddots & \\ & & & \ddots & \alpha_{n-1} \\ \alpha_n & & & & \lambda \end{pmatrix},$$

where $\lambda \in \mathbb{C}$ and $\alpha = (\alpha_1, \dots, \alpha_n) \in \mathbb{C}^n$. (Received September 25, 2012)

1086-15-1372 **Fumiko Futamura*** (futamura@southwestern.edu), 1001 E University Ave, Georgetown, TX 78626, and **Kendall Richards** and **Rick Denman**. *On Sharp Frame Diagonalization.*

We introduce a concept of diagonalization that uses not a basis of eigenvectors, but a frame. A frame is a generalization of a basis which is used in a number of signal and image processing applications. We describe several methods of constructing frames for frame diagonalization and prove a sharp result regarding the minimum size of a frame necessary to frame diagonalize a given matrix. (Received September 21, 2012)

1086-15-1563 **Martin S Copenhaver**, **Yeonhyang Kim**, **Cortney Logan**, **Kyanne Mayfield** and **Sivaram K. Narayan*** (sivaram.narayan@cmich.edu), Department of Mathematics, Central Michigan University, Mount Pleasant, MI 48859, and **Jonathan Sheperd**. *Maximum Robustness and Surgery of Frames in Finite Dimensions.*

We consider frames in a finite-dimensional Hilbert space where frames are exactly the spanning sets of the vector space. We present a method to determine the maximum robustness of a frame. We present results on tight subframes and surgery of frames. We also answer the question of when length surgery resulting in a tight frame set is possible. (Received September 23, 2012)

1086-15-1629 **Paul Sundheim*** (paul.sundheim@uwc.edu), 1500 University Drive, Waukesha, WI 53188. *A Multiplicative Determinant for 2^m -Dimensional Matrices.* Preliminary report.

A multiplication for $n = 2^m$ dimensional matrices is defined by association with a system of n dimensional hypercomplex numbers. A multiplicative, multi-linear determinant is then derived from the system. Total anti-symmetry and zeros of the determinant will also be discussed. (Received September 23, 2012)

1086-15-1633 **Tyler J. Moran*** (tjmoran@email.wm.edu) and **Ilya M. Spitkovsky** (ilya@math.wm.edu). *On almost normal matrices.*

Let an n -by- n matrix A be almost normal in a sense that it has $n - 1$ orthogonal eigenvectors. The properties of its numerical range $W(A)$ and Aluthge transform Δ are explored. In particular, it is proven that for unitarily irreducible almost normal A , $W(A)$ cannot have flat portions on the boundary and $\Delta(A)$ is not normal (the latter, under the additional conditions that $n > 2$ and A is invertible). In passing, the unitary irreducibility criterion for A , almost normality criterion for A^* , and the rank formula for the self-commutator $A^*A - AA^*$ are established. (Received September 23, 2012)

1086-15-1699 **Tobias R Pecher*** (tpecher@math.upb.de), Institut für Mathematik, Universität Paderborn, Warburger Str. 100, 33098 Paderborn, Germany. *Howe duality and Multiplicity-free actions.*

Let V be a finite dimensional representation of a reductive group G . The geometric problem, whether there is a Zariski open B -orbit in V (i.e., if V is spherical) is equivalent to the multiplicity-freeness of the symmetric algebra of (the dual of) V . It is also natural to consider the question when the exterior algebra of V is multiplicity-free. Unlike in the symmetric case, there is no geometric counterpart of this condition. However, the lists of multiplicity-free symmetric and exterior algebras are intimately related to each other.

The purpose of this talk is to give an explanation of this phenomenon by tracing back (skew) multiplicity-free actions to realizations of Howe dual pairs. We also discuss further applications of this approach to harmonic analysis and multiplicity-freeness results for Lie superalgebras. (Received September 24, 2012)

- 1086-15-1911 **Michael F Minner*** (mfm74@drexel.edu), Drexel University Department of Mathematics, Korman Center Room 206, 15 S 33rd Street, Philadelphia, PA 19104. *Sparse Signal Recovery and Remote Sensing.*

The purpose of remote sensing is to acquire information about an object through the propagation of electromagnetic waves, specifically radio waves for radar systems. These systems are constrained by the Nyquist sampling rate required to guarantee efficient recovery of the signal. Recent advancements of Compressive Sensing offer a means of efficiently recovering such signals with fewer measurements. In this talk, we will present several key concepts of Compressive Sensing and highlight its applicability to radar. (Received September 24, 2012)

- 1086-15-1936 **James E Gossell*** (jeg84240@ucmo.edu). *Non-unique Factorizations of Square Matrices.* Preliminary report.

While factorization in commutative semigroups has been well-studied, very little literature exists concerning factorization in the non-commutative setting. We will discuss factorization in certain subsemigroups of $M_n(\mathbb{Z})$, the semigroup of $n \times n$ integer-valued matrices with operation given by usual matrix multiplication. In particular, we will compute several important factorization-theoretic invariants. We also extend our study to $M_n(D)$ where D is any principle ideal domain. (Received September 24, 2012)

- 1086-15-2207 **Dominique Guillot*** (dguillot@stanford.edu), **Apoorva Khare** (khare@stanford.edu) and **Bala Rajaratnam** (brajarat@stanford.edu). *Functions operating on sparse positive definite matrices encoded by graphs.*

We characterize entrywise real functions of matrices leaving invariant the cone of positive semidefinite matrices with prescribed structure of zeros encoded by a graph. This extends classical and important results by Rudin, Schoenberg, and others, in the case of complete graphs. Our results show in many cases that such functions are necessarily analytic with positive coefficients. The techniques used involve an interesting interplay between complex analysis, spectral theory, and harmonic analysis. In addition to the inherent theoretical interest, this problem has important consequences in machine learning (via kernels), in regularization of covariance matrices, and in the study of Toeplitz operators. (Received September 25, 2012)

- 1086-15-2260 **Sabine Burgdorf*** (sabine.burgdorf@epfl.ch), EPFL, SB-MATHGEOM-EGG, Station 8, 1015 Lausanne, Switzerland. *Tracial moment problems related to Connes' embedding problem.*

The tracial moment problem is the problem of characterizing tracial linear functionals on the free polynomial ring over the real or complex numbers which are induced by integration with respect to some positive measure. This problem can be considered in different frameworks, e.g. tracial moments of a probability measure on hermitian matrices of finite size, or obtained by taking traces in a finite von Neumann algebra. I will present several aspects of tracial moment problems which are related to the embedding problem of Connes on von Neumann algebras and give an overview on the current state of knowledge on these problems. (Received September 25, 2012)

- 1086-15-2304 **Edward D. Hanson*** (hanson@math.wisc.edu), University of Wisconsin, Department of Mathematics, 480 Lincoln Dr., Madison, WI 53706. *Characterizations of Leonard Pairs.*

Roughly speaking, a Leonard pair can be thought of as an algebraic generalization of a Q -polynomial distance-regular graph. In this talk, we will cover several characterizations of Leonard pairs that utilize this notion. (Received September 25, 2012)

- 1086-15-2366 **John R Greene*** (jgreene@d.umn.edu), Department of Mathematics and Statistics, 1117 University Drive, University of Minnesota Duluth, Duluth, MN 55812. *Traces of matrix products.*

Given two noncommuting matrices, A and B , it is well known that AB and BA have the same trace. This extends to cyclic permutations of products of A 's and B 's. We show here that for 2×2 matrices A and B , whose elements are independent random variables with standard normal distributions, the probability that $Tr(ABAB) > Tr(A^2B^2)$ is exactly $\frac{1}{\sqrt{2}}$. For $n \times n$ matrices, we give tables from computations suggesting that the probability that $Tr(ABAB) > Tr(A^2B^2)$ is still roughly .7, though we do not know the exact value when $n > 2$. (Received September 25, 2012)

- 1086-15-2386 **Blake A Hunter*** (blakehunter@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *Social Network Clustering of Sparse Data.*

Trillions of devices around the world are continuously producing exabytes of data every day. The impact of search engines has been enormous, but there is also a parallel development in the applications of these methods to other related problems concerning the extraction of knowledge from large datasets. Data mining

is the mathematics, methodologies and procedures used to extract knowledge from large datasets. While this includes topics related to search engines it is mainly devoted to the more general problem of finding features and structure in a dataset. There are many active scientific fields, including pure and applied mathematics, statistics, computer science and engineering with numerous applications such as finance, the social sciences, and the humanities. Spectral embedding uses eigenfunctions of a Laplace operator (or related graph affinity matrix) for extracting the underlying global structure of a dataset. This talk will give an introduction to spectral embeddings. Applications presented will include clustering LA street gang members based on sparse observations of where and who they are seen with. (Received September 25, 2012)

1086-15-2475 **Justin Dickinson Marks*** (justmarks@gmail.com), Beaver Creek, OH. *Flag Mean of Generalized Grassmann Manifold Points.*

The geometrically elegant Stiefel and Grassmann manifolds have become organizational tools for data applications, such as illumination spaces for faces in digital photography. Modern data analysis involves increasingly large-scale data sets, both in terms of number of samples and number of features per sample. In circumstances such as when large-scale data has been mapped to a Stiefel or Grassmann manifold, the computation of mean representatives for clusters of points on these manifolds is a valuable tool for compression and statistical analysis.

Mean-finding algorithms which follow the theme of the Karcher mean are iterative in nature, and rely upon inversely related maps that operate between the manifold and the tangent bundle. These maps are informed by the geometric definition of the tangent bundle and the normal bundle. In this talk, we describe a method for determining a mean representative for a cluster of points on a generalized Grassmann manifold. The *Flag Mean* algorithm, which relies on the solutions of an eigenvector problem, produces a mean subspace of arbitrary dimension. We note a fascinating connection between the Flag Mean and Multi-set Canonical Correlation Analysis, and apply the Flag Mean to digital images of faces. (Received September 25, 2012)

1086-15-2835 **Michael T Zowada*** (mtz6@nau.edu), 901 S. O'Leary St. Apt. 67, Flagstaff, AZ 86001. *An Extension of Yang's Product Construction of Hadamard Matrices.*

In 1986, Yang developed an elementary technique for constructing Hadamard-like higher-dimensional arrays from smaller two-dimensional Hadamard matrices. This talk will show how Yang's "product construction" actually extends to arrays with complex entries. (Received September 25, 2012)

1086-15-2873 **Troy Banks*** (tvbanks@salisbury.edu), Department of Math and Computer Science, Salisbury University, 1101 Camden Ave, Salisbury, MD 21801. *On the structure of a class of Invariant Kernels.*

We study the structure of a certain class of Toeplitz-like positive definite kernels on the free semigroup on N generators. We explore some possible applications to multiscale processes and to learning with kernels. Associated classes of orthogonal polynomials are also investigated. (Received September 25, 2012)

1086-15-2905 **Gregory V Bard*** (bardg@uwstout.edu), Dept. of Math., Stat., and Comp. Sci., Jarvis Hall Science Wing, Menomonie, WI 54751, and **Miles Crocker** (crockerm6960@my.uwstout.edu), Dept. of Math., Stat., and Comp. Sci., Jarvis Hall Science Wing, Menomonie, WI 54751. *Pivoting Strategies in Sparse Gaussian Eliminations done mod p and their Impact upon Various Computer Algebra Tasks.* Preliminary report.

The topic of sparse linear algebra is thoroughly studied and deservedly so. The level of sophistication achieved in the best algorithms is extraordinary but many of these algorithms are entirely inapplicable mod p . Linear algebra mod p suffers from a number of maladies, including the existence of non-zero vectors that are orthogonal to themselves. Yet, linear algebra lies at the heart of numerous computer algebra processes, ranging from Groebner Bases to LLL and many things in between.

This research inquires as to the best methods for handling sparse matrices mod p efficiently. We present extensive experimental results comparing and contrasting various strategies known. Many standard methods are surprisingly sub-optimal compared to alternatives that are only slightly more complex. (Received September 26, 2012)

1086-15-2933 **Eric Cawi** (ecawi@gmu.edu), 4450 Rivanna River Way, Fairfax, VA 22030, and **John Ensley*** (john_ensley@brown.edu). *Paleoclimatology.*

In climate change research, it is important to utilize accurate historical temperature approximations. Most methods use proxies such as tree rings to develop their approximations. We study these methods to develop error bounds for the estimates and discover the effect of adding other explanatory variables like carbon dioxide. (Received September 26, 2012)

1086-15-2952 **Ben Sebuufu*** (ben.sebuufu@gordon.edu), 255 Grapevine Road, wenham, MA 01984, and **Tyesha Hall**. *Tchoukaillon: A single player Mancala game.*

Many interesting results on two-player sowing games, such as Mancala, have been discovered via brute-force computational analysis; but, a mathematical analysis of these games has proved to be difficult for, primarily, two reasons: the types of permissible moves, while small, produce a great variety of different board states, and the competing strategies between the two players depend on a (not fully understood) balance between short-term gains and the, ultimate, long-term gain of winning the game.

In order to better understand these Mancala type games, we restrict our attention to certain single-player sowing games in which the types of permissible moves are limited, and the number of strategies for a single player is small.

In this poster, we give results on two such restricted single-player games: Tchoukaillon and Tchoukaillon with wrapping. As a sample of some of our results, we prove that in Tchoukaillon the sequence of bins played exhibits a certain regularity, and in Tchoukaillon with wrapping we prove a certain interesting 'negative' result. (Received September 26, 2012)

16 ► Associative rings and algebras

1086-16-98 **Peter J McNamara*** (petermc@math.stanford.edu). *Finite dimensional representations of KLR algebras.*

Khovanov-Lauda-Rouquier algebras are a family of algebras that appear in categorifying quantum groups. I will talk about the category of finite-dimensional representations of these algebras. This involves classifying the simple representations, relating these to PBW bases, giving some understanding of higher Ext groups, and discussing the related combinatorial structures. (Received July 16, 2012)

1086-16-339 **Feroz Siddique*** (fsiddiq2@slu.edu), Department of Mathematics and Computer Sc., 220 N. Grand Blvd, Saint Louis, MO 63103, and **Ashish K Srivastava** (asrivast3@slu.edu), Department of Mathematics and Computer Sc., 220 N. Grand Blvd, Saint Louis, MO 63103. *Decomposing Elements of a Right Self Injective Ring.*

It was proved independently by both Wolfson [An ideal theoretic characterization of the ring of all linear transformations, Amer. J. Math. 75 (1953), 358-386] and Zelinsky [Every Linear Transformation is Sum of Nonsingular Ones, Proc. Amer. Math. Soc. 5 (1954), 627-630] that every linear transformation of a vector space V over a division ring D is the sum of two invertible linear transformations except when V is one-dimensional over \mathbb{Z}_2 . This was extended by Khurana and Srivastava [Right self-injective rings in which each element is sum of two units, J. Algebra and its Appl., Vol. 6, No. 2 (2007), 281-286] who proved that every element of a right self-injective ring R is the sum of two units if and only if R has no factor ring isomorphic to \mathbb{Z}_2 . In this paper we prove that if R is a right self-injective ring, then for each element $a \in R$ there exists a unit $u \in R$ such that both $a + u$ and $a - u$ are units if and only if R has no factor ring isomorphic to \mathbb{Z}_2 or \mathbb{Z}_3 . (Received September 25, 2012)

1086-16-583 **Aaron D Lauda*** (lauda@usc.edu), University of Southern California, 3620 S. Vermont Ave, KAP 108, Los Angeles, CA 90089-2532. *Odd structures arising from categorified quantum groups.*

Looking for higher structure in representation theory led to the discovery of categorified quantum groups. These algebraic structures have a close connection to knot theory via Khovanov homology and other link homology theories. Using ideas from knot theory one can obtain new "odd" versions of categorified quantum groups that lead to surprising new "odd" structures in geometric representation theory including odd analogs of the cohomology of the Grassmannian and Springer varieties. (Joint with Alex Ellis, Mikhail Khovanov, and Heather M. Russell) (Received September 07, 2012)

1086-16-585 **Aaron D Lauda*** (lauda@usc.edu), University of Southern California, 3620 S. Vermont Ave, KAP 108, Los Angeles, CA 90089-2532. *From skew Howe duality to knot invariants.*

Using a version of Howe duality for exterior algebras, Cautis, Kamnitzer, and Licata showed that the braiding (or R-matrix) for tensor products of minuscule representations of $\mathfrak{sl}(n)$ can be obtained using the Weyl group action. This action can be reinterpreted in terms of planar diagrams called webs leading to the usual diagrammatic description of associated knot invariants. We will discuss how to lift this entire setup to obtain link homology theories from categorified quantum groups using categorical skew Howe duality. (Joint with Hoel Queffelec and David Rose) (Received September 07, 2012)

1086-16-665 **Sabin Cautis*** (cautis@usc.edu), Mathematics Department, University of Southern California, 3620 South Vermont Ave., Los Angeles, CA 90089. *The representation theory of Hecke algebra via infinite twists.*

We discuss infinite twists and their role in defining Young symmetrizers. (Received September 10, 2012)

1086-16-666 **Padmini Veerapen*** (pveerapen@uta.edu), Department of Mathematics, University of Texas, P.O. Box 19408, Arlington, TX 76019-0408, and **Michaela Vancliff** (mvancliff@uta.edu), Department of Mathematics, University of Texas, P.O. Box 19408, Arlington, TX 76019-0408. *Point Modules over Graded Skew Clifford Algebras.* Preliminary report.

In a recent paper by T. Cassidy & M. Vancliff, the authors introduce a quantized analog of a graded Clifford algebra called a graded skew Clifford algebra (GSCA). In this talk, we use our notion of μ -rank defined on noncommutative quadratic forms (in Vancliff & Veerapen, 2012) to show that the point modules over a regular GSCA, A , are determined by the quadratic forms of μ -rank at most two in the Koszul dual of A . (Received September 10, 2012)

1086-16-762 **Kenneth Lee Price*** (pricek@uwosh.edu), 800 Algoma Boulevard, Department of Mathematics, University of Wisconsin Oshkosh, Oshkosh, WI 54901. *Good Gradings of Incidence Rings.*

An incidence ring is a ring of functions defined on a preordered set with relations. For a nontrivial group G there is often a subset of the relations, called a G -grading set, which completely determines all good G -gradings of an incidence ring. The speaker will present an extension of Molli Jones's construction to good group gradings for incidence rings over preorders with crosscuts of length one or two. (Received September 12, 2012)

1086-16-856 **Jason D Gaddis*** (jdgaddis@uwu.edu). *PBW deformations of Artin-Schelter regular algebras.*

In this talk, we explore properties of PBW deformations of Artin-Schelter regular algebras via their homogenizations. We explain how geometric tools of regular algebras can be used to determine simple modules of deformations. A classification in dimension 2 is presented as well as several examples in dimension 3. (Received September 14, 2012)

1086-16-1180 **Eric Brussel*** (ebrussel@calpoly.edu). *The Brauer group of the function field of a curve over a complete discrete valuation ring.*

Let F be the function field of a smooth curve over a local field. We prove the following for a number n that is coprime to the residue characteristic: a) The \mathbb{Z}/n -cyclic length in the n -torsion of $\text{Br}(F)$ is two; and b) If n is prime then all F -division algebras of degree n are cyclic. The second result was first proved by Saltman. We prove some results when the local field is replaced by a field that is henselian with respect to a discrete valuation of rank one. (Received September 19, 2012)

1086-16-1235 **John Voight*** (jvoight@gmail.com), Department of Mathematics, University of Vermont, 16 Colchester Ave, Burlington, VT 05401. *The Brauer monoid of quaternion rings.*

The 2-torsion of the Brauer group of a field of characteristic not 2 is generated by quaternion algebras, by a theorem of Merkurjev. We consider a monoid extension of this subgroup: it is generated by a larger class of quaternion rings, allowing for degeneration, and is therefore closed under taking limits. (Received September 20, 2012)

1086-16-1374 **Zajj B. Daugherty** (zajj.b.daugherty@dartmouth.edu), Dartmouth College, Mathematics Department, 6188 Kemeny Hall, Hanover, NH 03755, and **Rosa C. Orellana*** (rosa.c.orellana@dartmouth.edu), Dartmouth College, Mathematics Department, 6188 Kemeny Hall, Hanover, NH 03755. *The quasi-partition algebra.*

In this talk we introduce the quasi-partition algebra, $QP_k(n)$. We construct a basis thus showing that the dimension of the algebra is the number of set partitions of $2k$ that do not have blocks of size one. We also discuss its representation theory, showing among other things that the irreducible representations are indexed by partitions of $0, 1, 2, \dots, k$. (Received September 21, 2012)

- 1086-16-1499 **Manizheh Nafari*** (manizheh.nafari@gmail.com), The University of Toledo, Department of Mathematics and Statistics, MS9, 2801 W. Bancroft Street, Toledo, OH 43606-3390, and **Michaela Vanccliff** (vanccliff@uta.edu), University of Texas at Arlington, P.O.Box 19408, Arlington, TX 76019. *Regular Graded Skew Clifford Algebras that are Twists of Regular Graded Clifford Algebras*.

M. Artin, W. Schelter, J. Tate, and M. Van den Bergh introduced the notion of non-commutative regular algebras, and classified regular algebras of global dimension 3 on degree-one generators by using geometry (i.e., point schemes) in the late 1980s. Recently, T. Cassidy and M. Vanccliff generalized the notion of a graded Clifford algebra and called it a graded skew Clifford algebra.

In this talk, We prove that if A is a regular graded skew Clifford algebra and is a twist of a regular graded Clifford algebra B by an automorphism, then the subalgebra of A generated by a certain normalizing sequence of homogeneous degree-two elements is a twist of a polynomial ring by an automorphism, and is a skew polynomial ring. We also present an example that demonstrates that this can fail when A is not a twist of B . (Received September 22, 2012)

- 1086-16-1655 **Georgia Benkart*** (benkart@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, Madison, WI 53706, **Samuel Lopes** (slopes@fc.up.pt), Centro de Matematicas, Universidade do Porto, 4169-007 Porto, Portugal, and **Matthew Ondrus** (mattondrus@weber.edu), Mathematics Department, Weber State University, Ogden, UT 84408. *Representations and Combinatorics on the Weyl Side*.

The Weyl algebra arises in many different settings in mathematics and physics. This talk will focus on a family of subalgebras of the Weyl algebra, which can be viewed as algebras of differential operators with polynomial coefficients. In our joint work, we have investigated the structure of these algebras and determined their irreducible representations. There are interesting (non-standard) connections with the lattice of partitions. (Received September 23, 2012)

- 1086-16-1802 **Colin J Ingalls*** (cingalls@unb.ca), Department of Mathematics, University of New Brunswick, Tilley Hall, Fredericton, NB E3B 2C8, Canada, and **Daniel Chan**. *Noncommutative surfaces and curves of finite representation type*. Preliminary report.

This is joint work with Daniel Chan. Local orders of global dimension two, over surfaces of finite representation type have been classified geometrically by Artin and by AR quivers by Reiten and Van den Bergh. We present a third classification via central extensions of finite subgroups of . This methods easily allows one to link all three classifications. We further classify noncommutative curves of finite representation type using noncommutative matrix factorizations and the classification of orders. (Received September 24, 2012)

- 1086-16-1830 **Anthony Ruozzi*** (anthony@mathcs.emory.edu). *Essential Dimension and the Brauer Group*.

Interest in essential dimension problems has been growing in recent years. This should not be surprising since the essential dimension captures quite elegantly the “least number of parameters” needed to define a wide range of algebraic objects. Calculations of this number require most of our algebraic and geometric machinery. Consequently, what began as a problem in Galois cohomology and representation theory now has connections to versal torsors, stacks, motives, birational geometry, and invariant theory. This talk will survey the basics of essential dimension and how it relates to central simple algebras. I will briefly discuss what is known, more of what is unknown, and how to actually compute some bounds on the essential p -dimension of PGL_p^n . (Received September 24, 2012)

- 1086-16-1904 **Christopher James Wilson*** (cjwilson@butler.edu), Jordan Hall 270, Butler University, 4600 W. Sunset Avenue, Indianapolis, IN 46208. *Orders containing a weak crossed product order over a discrete valuation ring*. Preliminary report.

A *weak* crossed product over a discrete valuation ring is one whose cocycle is allowed to take any nonzero value (so nonunit cocycle values are permitted).

Let R be a discrete valuation ring with field of fractions F , and let S be the integral closure of R in a tamely ramified Galois extension K of F . We give results and examples concerning those orders in the crossed product algebra $\sum Kx_\sigma$ that contain a weak crossed product order $\sum Sx_\sigma$ in the case that S is local. (Received September 24, 2012)

- 1086-16-2116 **Zajj B Daugherty*** (zajj.b.daugherty@dartmouth.edu), 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755. *Centralizer properties of the affine Hecke algebra of type C.* Preliminary report.

Several diagram algebras (like group algebras of symmetric groups or braid groups) arise as endomorphisms of tensor spaces that commute with classical Lie groups, Lie algebras, quantum groups, etc.. The commutator relationships provide amazing tools for studying the algebras' representation theory, and reveal beautiful combinatorial structure. This work provides a bridge between results in quantum physics (and the two-boundary Temperley-Lieb algebra), the representation theory of the affine Hecke algebra of type C, and the combinatorics developed in thesis work on the degenerate two-boundary Hecke algebra, establishing a transfer of useful information between these different points of view. (Received September 24, 2012)

- 1086-16-2319 **David Harbater*** (harbater@math.upenn.edu), Department of Mathematics, University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA 19104-6395, and **Julia Hartmann** (hartmann@matha.rwth-aachen.de) and **Daniel Krashen** (dkrashen@math.uga.edu). *Patching and local-global principles for Brauer groups.*

Using patching methods, local-global principles can be obtained for Brauer groups of function fields of curves over complete discretely valued fields. Over such function fields and related fields (such as two-variable Laurent series fields), this leads to results concerning the period-index problem. Motivated by work of Kato, these methods also lead to local-global principles for analogs of the Brauer group in higher cohomology over function fields as above, with applications to torsors and other structures such as Albert algebras. (Received September 25, 2012)

- 1086-16-2519 **Gabriel Feinberg*** (gabriel.feinberg@gmail.com) and **Kyu-Hwan Lee**. *Homogeneous Representations of Type A Khovanov-Lauda-Rouquier Algebras.*

The Khovanov-Lauda-Rouquier (KLR) algebra arose out of attempts to categorify quantum groups. Kleshchev and Ram proved a result reducing the representation theory of these algebras to the study of irreducible *cuspidal* representations. In type A, these cuspidal representations are part of a larger class of homogeneous representations.

We'll prove a bijection between these homogeneous representations and the set of Dyck paths, and share some further classification results. (Received September 25, 2012)

- 1086-16-2572 **Colleen Duffy*** (duffy@uwec.edu). *Algebras associated to finite Coxeter groups.*

We can construct a graded algebra, $A(\Gamma)$, associated to a directed Hasse graph, Γ , of a regular polytope. This algebra is constructed by taking the quotient of the free algebra on the set of edges of the graph by the relations given by equating two directed paths having the same initial and final vertices. The Coxeter group, \mathcal{C} , which is the symmetry group of the polytope acts naturally on the graph, and so on each of the homogeneous subspaces of the algebra. For each element in the symmetry group, we find the Hilbert series of the graded subalgebra fixed under the action, called the graded trace generating function. We can use these functions to obtain the multiplicities of the irreducible \mathcal{C} -modules in the graded algebra.

This talk will focus on the algebra associated to the n -dimensional hypercube, $\mathcal{C} = [4, 3^{n-2}]$. We will discuss the 'nice' formulas we found for the graded trace functions and mention methods used to find them. At the end we will give the results for other regular polyhedra and how all these results can be extended. (Received September 25, 2012)

- 1086-16-2574 **Susan J. Durst*** (sdurst@math.rutgers.edu). *Algebras Associated to Ranked Posets.*

Given a poset P , there exists an associated algebra $A(P)$, initially introduced for $P = 2^{[n]}$, the Boolean lattice, as a tool for studying the behavior of the pseudoroots of degree- n polynomials over non-commutative division rings. Here we will explore the structure of $A(P)$ for a wider class of ranked posets. In particular, we will discuss how the structure of P is reflected in the algebra $A(P)$, and present several classes of posets which are uniquely defined by their algebras $A(P)$. (Received September 25, 2012)

- 1086-16-2587 **Thomas Benedict Williams*** (tbwillia@usc.edu). *Azumaya orders do not always exist.* Azumaya algebras over schemes generalize central simple algebras over fields, and the taking of equivalence classes allows the generalization of the Brauer group to schemes. Suppose X is a regular noetherian integral scheme, with field of fractions K . Suppose A is a central simple K -algebra, and suppose further that the class of A in the Brauer group $\text{Br}(K)$ lies in the image of the functorial map $\text{Br}(X) \rightarrow \text{Br}(K)$. We consider the problem of extending A to X ; specifically, we ask if it is possible to find an Azumaya algebra whose restriction to the generic point is A . It has been known for a long time that this is possible if the dimension of X is less than

three. By use of obstruction theory, we exhibit a complex affine variety X and a central simple algebra over the fraction field for which no extension exists. (Received September 25, 2012)

1086-16-2667 **Eric Brussel, Kelly McKinnie*** (kelly.mckinnie@mso.umt.edu) and **Eduardo Tengan**. *Generating the Brauer Group of the function field of a p -adic curve with cyclic algebras*. Preliminary report.

In this talk we will discuss recent results about the number of cyclic algebras one needs to generate the Brauer group of the function field of a p -adic curve. (Received September 25, 2012)

17 ► *Nonassociative rings and algebras*

1086-17-725 **Seok-Jin Kang, Kyu-Hwan Lee, Hansol Ryu and Ben Salisbury*** (bsalisbury@ccny.cuny.edu). *A combinatorial description of the affine Gindikin-Karpelevich formula of type $A_n^{(1)}$* .

The classical Gindikin-Karpelevich formula appears in Langlands' calculation of the constant terms of Eisenstein series on reductive groups and in Macdonald's work on p -adic groups and affine Hecke algebras. The formula has been generalized in the work of Garland to the affine Kac-Moody case, and the affine case has been geometrically constructed in a recent paper of Braverman, Finkelberg, and Kazhdan. On the other hand, there have been efforts to write the formula as a sum over Kashiwara's crystal basis or Lusztig's canonical basis, initiated by Brubaker, Bump, and Friedberg. In this paper, we write the affine Gindikin-Karpelevich formula as a sum over the crystal of generalized Young walls when the underlying Kac-Moody algebra is of affine type $A_n^{(1)}$. The coefficients of the terms in the sum are determined explicitly by the combinatorial data from Young walls. (Received September 11, 2012)

1086-17-1168 **Nathaniael J Manning***, 585 King Edward Ave, Ottawa, Ontario K1N6Y7, Canada, and **Ghislain Fourier and Alistair Savage**. *Global Weyl modules for equivariant map algebras*.

A family of infinite-dimensional modules called global Weyl modules were defined and studied by Chari and Pressley over loop algebras $\mathfrak{g} \otimes \mathbb{C}[t, t^{-1}]$, where \mathfrak{g} is a simple complex finite-dimensional Lie algebra. Feigin and Loktev extended the definition to algebras of the form $\mathfrak{g} \otimes A$, where A is the coordinate ring of an affine variety. In collaboration with Fourier and Senesi, global Weyl modules were defined and studied for the first time for loop algebras which have been twisted by a graph automorphism of the Dynkin diagram. This talk, which presents joint work with Fourier and Savage, focuses on the generalization of these modules to the setting of equivariant map algebras: the fixed points $(\mathfrak{g} \otimes A)^\Gamma$, where Γ is a finite group acting on \mathfrak{g} and A by automorphisms. (Received September 19, 2012)

1086-17-1248 **Melissa M Tolley*** (mmtolley@ncsu.edu). *Connecting A_∞ and L_∞ Algebras*. Preliminary report.

We first give definitions of A_∞ and L_∞ algebras, showing basic connections between the two. From here, we recall Hiroshige Kajiura and Jim Stasheff's definition of strong homotopy derivations of an A_∞ algebra, create the corresponding definition for L_∞ algebras, then look at the connections between the two derivations. (Received September 20, 2012)

1086-17-1314 **Lucas A David-Roesler*** (roesler@lvc.edu), Mathematics Department, 101 N. College Avenue, Lebanon Valley College, Annville, PA 17003, and **Ralf A Schiffer**. *A method to calculate an invariant of Avella-Alaminos and Geiss using surface triangulations*.

In 2008 Avella-Alaminos and Geiss introduced a combinatorial invariant for gentle algebras which is invariant under derived equivalences. This invariant comes from a calculation on the presentation of the algebra by a quiver with relations. We are interested in quivers with relations that arise from triangulations of surfaces with boundary. The algebras corresponding to these triangulations are gentle and play an important role in the cluster algebra that may be associated to the surface. We will show how to calculate this invariant using only the information coming from the triangulation. Further, we will show how this calculation can also be extended to two other classes of algebras: the m -cluster tilted algebras and surface algebras. (Received September 21, 2012)

1086-17-1573 **Corina Calinescu*** (ccalinescu@citytech.cuny.edu), **James Lepowsky** and **Antun Milas**. *Principal subspaces of standard modules for twisted affine Lie algebras.*

We discuss vertex-algebraic structure and characters of principal subspaces of certain representations for twisted affine Lie algebras. This talk is based on joint work with James Lepowsky and Antun Milas. (Received September 23, 2012)

1086-17-1940 **Irfan Bagci** and **Samuel H Chamberlin*** (samuel.chamberlin@park.edu), Park University, 8700 NW River Park Dr. #30, Parkville, MO 64152. *Kostant map superalgebras.*

Given a classical Lie superalgebra \mathfrak{g} and a complex commutative associative algebra with unity A , we exhibit a Kostant superalgebra (integral form) for the universal enveloping superalgebra of the map superalgebra $\mathfrak{g} \otimes A$ and an explicit Poincaré-Birkhoff-Witt-like integral basis for this integral form. This is achieved via explicit commutation formulas in the universal enveloping superalgebra. (Received September 24, 2012)

1086-17-2091 **Kelly C Aman*** (kelly.aman@mavs.uta.edu). *Simplifying Kunth Cubical Arrays for Semifields.*

Semifields are finite dimensional vector spaces over finite fields with non-associative vector multiplication. There are clearly only a finite number of isomorphism classes of semifields of any given order, but this number quickly grows too large to warrant investigation, as there are 376971 non-isomorphic semifields of order 64, and even more for higher orders. For this reason, the published results regarding semifields have focused on isotopism classes instead of isomorphism classes (there are only 332 non-isotopic semifields of order 64). Unfortunately, isotopic semifields can have vastly different algebraic properties, such as a commutative semifield being isotopic to a non-commutative semifield.

Clearly, a method for studying the isomorphism classes of semifields is needed. Knuth's cubical arrays provide a powerful tool for studying semifields and their isomorphisms, but are somewhat complicated and difficult to fully understand. By mapping each element of the vector space to an integer, we can simplify the cubical array into a matrix which is immediately useful for performing semifield multiplication, and can be used to study the isomorphism classes of semifields. (Received September 24, 2012)

1086-17-2198 **Gabriel C. Drummond-Cole*** (gabriel@math.northwestern.edu). *A Poincaré polynomial governing Lie bialgebras.* Preliminary report.

A Lie bialgebra is a vector space which is simultaneously a Lie algebra and a Lie coalgebra such that the bracket and cobracket satisfy a certain compatibility relation. Understanding the spaces of possible operations that can be “built out of” the bracket and cobracket is important for homotopy theory and has connections to geometry. In this talk, I'll tell you the dimensions of some of these spaces of operations, indicate the representation theory used to obtain them, and mention a connection to Wilson quotients. (Received September 25, 2012)

1086-17-2397 **Tevian Dray*** (tevia@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331, **John Huerta** (john.huerta@anu.edu.au), Mathematical Sciences Institute, The Australian National University, Canberra, ACT 0200, Australia, **Corinne A. Manogue** (corinne@physics.oregonstate.edu), Department of Physics, Oregon State University, Corvallis, OR 97331, and **Robert A. Wilson** (r.a.wilson@qmul.ac.uk), School of Mathematical Sciences, Queen Mary University of London, London, E1 4NS, United Kingdom. *The symplectic nature of E_7 .* Preliminary report.

Freudenthal and Tits independently showed how to construct a Lie algebra from a pair of division algebras, with the exceptional Lie algebras corresponding to the octonions. The first two rows of this “magic square” are described by the Lie algebras of special unitary and linear groups, and a description of the third row in terms of the Lie algebras of (generalized) symplectic groups is also known. At the group level, the first two rows are well understood, including a geometric understanding of the minimal representations of F_4 and E_6 in terms of the Albert algebra. In the third row, the minimal representation of E_7 consists of Freudenthal triples.

In this work, we outline a new description of Freudenthal triples in terms of “cubies”, the components of an antisymmetric rank-3 representation of (generalized) symplectic groups, thus providing a link between the two descriptions of the third row of the magic square, a unified, geometric interpretation of Freudenthal triples as a single object, and a new description of the minimal representation of E_7 .

In future work, we hope to extend this construction to the fourth row, ultimately providing a unified description of the full magic square. (Received September 25, 2012)

18 ► *Category theory; homological algebra*

1086-18-185 **Joel Smith*** (joelsmith1990@mail.fresnostate.edu). *The singular Temperley-Lieb category*. Preliminary report.

We introduce the *singular Temperley-Lieb category* **STL**, which is a strict tensor category and an extension of the classical Temperley-Lieb category (playing an essential role in constructing quantum invariants for tangles, and in particular, for knots and links). The objects of **STL** are even length sequences of $+$ and $-$ signs representing collections of oriented marked points on a line, and the morphisms are one-dimensional cobordisms between these collections of points. Specifically, the morphisms are oriented bivalent graphs with boundary such that bivalent vertices are either sources or sinks, and such that the orientation of edges agrees with the orientation of the end points.

We describe the collection of morphisms in **STL** via generators and relations, and to each morphism we associate a bimodule over a commutative ring by means of a certain two-dimensional Topological Quantum Field Theory.

This work is partially supported by the Undergraduate Research Grant program at California State University, Fresno under the supervision of Professor Carmen Caprau. (Received August 04, 2012)

1086-18-597 **Daniel Bravo, James Gillespie and Mark Hovey*** (mhovey@wesleyan.edu). *Generalizations of the stable module category*. Preliminary report.

For a quasi-Frobenius ring R , the stable module category is obtained by sending projective modules to zero. The associated model category structure on R -modules is perhaps the simplest interesting example of a model category. In this paper, we explore generalizations of the stable module category to broader classes of rings R , using model structures on chain complexes. One of these is Krause's stable derived category, but there are several others and the relationship between them remains unclear. They all coincide for Gorenstein rings R . (Received September 08, 2012)

1086-18-1026 **C. Joanna Su*** (jsu@providence.edu), Dept. of Mathematics and Computer Science, Providence College, Providence, RI 02918. *The Third and the Automatic Homotopy Exact Sequence of a Fibration in Module Theory*.

The homotopy theory of modules was developed by Peter Hilton in the 1950s, as a natural analog to the existing homotopy theory in algebraic topology. While the concept of a fibration in module theory seemed intuitive and induced a homotopy sequence, the 'expected' sequence failed to be discovered. Our search shows that in module theory a fibration induces not just one, but three homotopy sequences - the first, the expected, and the automatic homotopy exact sequences, respectively. Each sequence carries different features. The first and original sequence displays an isomorphism between the relative homotopy groups and the homotopy groups of the 'fiber'. The expected sequence both displays an analogous appearance to the homotopy sequence of a fibration in topology and inherits the characteristic isomorphism between the relative homotopy groups and the homotopy groups of the induced 'base space'. Here we discuss the third of the three homotopy sequences - the automatic sequence - which takes place in the projective homotopy theory of modules, whereas the other two sequences took place in the injective homotopy theory of modules. It turns out that the automatic sequence displays an isomorphism between the relative homotopy groups and the 'strong' homotopy groups of the fiber. (Received September 18, 2012)

1086-18-2219 **James Gillespie*** (jgillesp@ramapo.edu), Ramapo College, 505 Ramapo Valley Road, School of Theoretical and Applied Science, Mahwah, NJ 07430. *Completeness of the Gorenstein projective and injective cotorsion pairs*.

This is a report on a portion of joint work with Daniel Bravo and Mark Hovey on model structures for the stable derived category of a ring R . We see that every module over a Noetherian ring R has a special Gorenstein injective preenvelope. That is, the Gorenstein injectives form the right half of a complete cotorsion pair. On the other hand, we get the dual result concerning Gorenstein projective modules whenever R is coherent and satisfies that all flat modules have finite projective dimension. As we will point out, this is an extremely large class of rings. Moreover, there is a generalization as follows: Let R be any coherent ring. Then every R -module has both a special "Ding injective" preenvelope and a "Ding projective" precover. For the types of rings above, Ding injective = Gorenstein injective and Ding projective = Gorenstein projective. (Received September 25, 2012)

1086-18-2943 **Benjamin Cooper*** (benjamin.cooper@math.uzh.ch) and **Matt Hogancamp**. *Higher order Jones-Wenzl Projectors and Mapping Class Groups*.

Higher order Jones-Wenzl projectors can be constructed within Khovanov's framework for the categorification of the Jones polynomial. Together they form exceptional collections which control the categories underlying Khovanov homology. As a consequence we obtain Postnikov decompositions of all tangle invariants and some relation to automorphisms of surfaces. (Received September 26, 2012)

19 ► *K-theory*

1086-19-1909 **Clayton C. Sherman*** (csherman@missouristate.edu), Dept. of Mathematics, Missouri State University, Springfield, MO 65897. *K1 of an Exact Category by Mirror Image Sequences*.

We establish a presentation for K_1 of any small exact category \mathcal{P} , based on the notion of "mirror image sequence" originally introduced by Grayson in 1978; as part of the proof, we show that every element of $K_1(\mathcal{P})$ arises from a mirror image sequence. This provides an alternative to Nenashev's presentation in terms of "double short exact sequences." (Received September 24, 2012)

1086-19-1991 **Viraj Navkal*** (viraj@math.ucla.edu). *G-Theory of a Complete Local CM Ring of Finite CM Type*.

Let R be a complete local Cohen-Macaulay ring of finite Cohen-Macaulay type. By a theorem of Auslander and Reiten, the Grothendieck group of the category of maximal Cohen-Macaulay R -modules depends only on its Auslander-Reiten sequences. In this talk I will discuss an ongoing project to understand the relationship between the higher K -theory and Auslander-Reiten theory of such a category. (Received September 24, 2012)

1086-19-2689 **Mio I Alter*** (malter@math.utexas.edu). *Differential Circle Equivariant K-theory*. Preliminary report.

Differential cohomology theories of smooth manifolds geometrically refine classical cohomology theories by combining differential forms and integral cocycles to obtain local geometric and global topological information. Whereas the topological K -theory $K^0(M)$ is the ring of isomorphism classes of vector bundles, the differential K -theory $\hat{K}^0(M)$ consists of isomorphism classes of vector bundles with connection. When a smooth manifold M carries a smooth action of the circle group \mathbb{T} , equivariant K -theory, the K -theory of \mathbb{T} -equivariant vector bundles, captures equivariant topological information. We recall the Freed-Lott construction of differential K -theory and present a construction of differential \mathbb{T} -equivariant K -theory which captures equivariant geometric and topological information at once. (Received September 25, 2012)

20 ► *Group theory and generalizations*

1086-20-4 **Robert M. Guralnick*** (guralnic@usc.edu), University of Southern California, Department of Mathematics, 3620 Vermont Ave., Los Angeles, CA 90089-2532. *Generators and Relations for Finite Groups*.

Suppose that G is a group that can be generated by d elements. Then we can identify $G = F/R$ where F is a free group of rank d and R is a normal subgroup. We are interested in getting bounds for the minimal number of generators needed for G as well as r the minimal number of relations for G – i.e. the minimal number of elements of R that generate R as a normal subgroup of F . If G is finite, it is well known that $r \geq d$. These are very natural concepts that come up in studying groups. They are also useful in computational group theory and in applications of group theory to geometry and number theory.

We will mostly deal with finite groups and a critical case is for finite simple groups. We will discuss the result that all finite simple groups can be generated by two elements and extensions of this result. We will discuss some techniques using algebraic geometry and probabilistic methods. We will also discuss some recent results of the speaker with Kantor, Kassabov and Lubotzky on the number and length of relations required.

Finally, we will discuss these ideas in the context of profinite groups and connections with low degree cohomology. (Received August 30, 2012)

- 1086-20-118 **Joseph Kirtland*** (joe.kirtland@marist.edu), Department of Mathematics, Marist College, 3399 North Road, Poughkeepsie, NY 12601. *On Two Classes of Finite Inseparable p -Groups*. Preliminary report.

A finite group is *inseparable* if it does not split over any proper nontrivial normal subgroup; that is, if it has no nontrivial semidirect product decompositions. This talk investigates two classes of finite inseparable p -groups and, for $p \geq 3$, establishes a necessary and sufficient condition for inseparability. (Received July 24, 2012)

- 1086-20-125 **Arturo Magidin*** (magidin@member.ams.org), Department of Mathematics, University of Louisiana at Lafayette, 217 Maxim Doucet Hall, P.O. Box 41010, Lafayette, LA 70504-1010. *A group of class 2 and prime exponent is capable if its commutator subgroup is sufficiently large*.

Let G be a group of class 2, order p^n , and prime exponent. We prove a sufficient condition for capability of G (that is, for G to be a central quotient) that depends only on the size of $[G, G]$. (Received September 19, 2012)

- 1086-20-128 **Craig J Dodge*** (cdodge2@allegheny.edu). *New results on decomposable Specht modules*. Joint work with Dr. Matthew Fayers.

We present a new family of decomposable Specht modules for the symmetric group in characteristic 2. These Specht modules are labelled by partitions of the form $(a, 3, 1^b)$, and are the first new examples found for thirty years. Our method of proof is to exhibit summands isomorphic to irreducible Specht modules, by constructing explicit homomorphisms between Specht modules. (Received July 26, 2012)

- 1086-20-138 **Gerhard Rosenberger*** (gerhard.rosenberger@math.uni-hamburg.de), Fachbereich Mathematik, University of Hamburg, Bundesstrasse 55, 20146 Hamburg, Germany, and **Laura Ciobanu** and **Benjamin Fine**. *An Extension of a Theorem by B. Baumslag*.

Benjamin Baumslag proved that being fully residually free is equivalent to being residually free and commutative transitive. Gaglione and Spellman and independently Remeslennikov showed that this is also equivalent to being universally free. We extend this to classes of groups for which the analogous statements hold. (Received July 27, 2012)

- 1086-20-147 **Amanda A. Schaeffer Fry*** (mandi@math.arizona.edu), Tucson, AZ 85721. *Cross-Characteristic Representations of $Sp_6(2^a)$ and Their Restrictions to Proper Subgroups*.

We classify all pairs (V, H) , where H is a proper subgroup of $G = Sp_6(q)$, q even, and V is an ℓ -modular representation of G for $\ell \neq 2$ which is absolutely irreducible as a representation of H . This problem is motivated by the Aschbacher-Scott program on classifying maximal subgroups of finite classical groups. (Received July 28, 2012)

- 1086-20-179 **Persi Diaconis*** (diaconis@math.stanford.edu), Department of Statistics, Sequoia Hall, 390 Serra Mall, Stanford University, Stanford, CA 94305-4065. *On choosing coset representatives*. Preliminary report.

Normally, we try to show that the choice of coset representatives doesn't matter. But sometimes it does. Even in doing basic arithmetic, where cocycles are 'carries', the right choice can lead to less of a mess. For central extensions, Borodin, Fulman and I have shown that multiplying random elements leads to a 'carries' process which is one dependent and determinantal. Interesting groups, such as the Sylow 2-subgroup of the Suzuki group, lead to interesting point processes. Choosing coset representatives that minimize the number of carries leads to novel problems in arithmetic combinatorics, even for $\mathbb{Z}/10$ in $\mathbb{Z}/100$ (work with Shao and Soundararajan). (Received August 03, 2012)

- 1086-20-226 **Sangjib Kim** (skim@maths.uq.edu.au), School of Mathematics and Physics, The University of Queensland, St Lucia, QLD 4072, Australia, and **Victor Protsak*** (protsak@oswego.edu), Department of Mathematics, State University of New York at Oswego, Oswego, NY 13126. *On GL_n to GL_{n-2} Branching Multiplicity Spaces*.

Using Howe's reductive dual pair philosophy, we study the branching multiplicity spaces for the irreducible representations of the complex general linear group GL_n under its restriction to GL_{n-2} . These spaces admit hidden symmetries extending the natural GL_2 -action, namely, the Yangian $Y(\mathfrak{gl}_2)$ and the $(n-1)$ -fold product of \mathfrak{sl}_2 's. We connect the combinatorial description of the branching multiplicity spaces in terms of Gelfand-Tsetlin patterns with explicit formulas for differential operators realizing the hidden symmetries. (Received August 17, 2012)

1086-20-258 **Katherine Anne Bird*** (bird10000@gmail.com). *Dade's Ordinary Conjecture (DOC) for the Finite Special Unitary Groups.*

An ordinary character of a finite group G is the character of a representation of G over a field of characteristic 0. In the p -modular representation theory of G , where p is a prime dividing $|G|$, the ordinary irreducible characters of G are divided into disjoint sets called p -blocks which reflect the decomposition of the group algebra of G over a field of characteristic p into indecomposable two-sided ideals. An important problem is to classify the p -blocks. A first step is to count the number of ordinary characters in a block B .

The aim of DOC is to prove an alternating sum of the form

$$\sum_{C/G} (-1)^{|C|} k(N_G(C), B, d) = 0, \quad \forall d \geq 0$$

which counts the number of characters in B in terms of corresponding numbers in subgroups of G which are normalizers of chains of certain p -subgroups of G .

This has been shown for p -blocks, p dividing q , for $\mathrm{GL}_n(q)$, $\mathrm{SL}_n(q)$ and $\mathrm{U}_n(q)$. We prove DOC for $\mathrm{SU}_n(q)$. The main difficulties involved arise because the structure of the unitary groups is more complicated than that of the linear groups. The cancellations in the alternating sum in the unitary case are very different from those that occur in the general linear case. (Received August 14, 2012)

1086-20-286 **Lihua Huang*** (lihua.huang12@gmail.com), Buell Apartments 0368B, Rutgers, The State University of New Jersey, 55 Bevier Rd, Piscataway, NJ 08854, and **Ron Evans** (revans@ucsd.edu), Department of Mathematics, University of California, San Diego, La Jolla, CA 92093-0112. *The Stargate Switch.*

An episode of *Stargate SG-1* features a two-body mind-switching machine which will not work more than once on the same pair of bodies. (This is the same limitation suffered by the mind-switching machine in *Futurama*'s 2010 episode "The Prisoner of Benda".) The plot centers around two disjoint pairs of individuals who swap minds but subsequently wish the process could be reversed. The drama ends with a day-saving sequence of four mind swaps that returns everyone back to normal. We consider the more general situation where an arbitrary number of disjoint pairs swap minds. Using group theory, we present an algorithm for restoring all minds to their original bodies and prove it is optimal. (Received August 15, 2012)

1086-20-300 **Ashley Johnson***, Department of Mathematics, 203 Avery Hall, Lincoln, NE 68588-0130. *Closure Properties of Stackable Groups.* Preliminary report.

A Cayley graph is a geometric representation of a group that encodes the group elements and the relations between them. Studying the geometric properties of the Cayley graph can provide valuable information about the group. One such geometric property, recently introduced by Brittenham and Hermiller, is called *stackability*. Stackability captures the geometric properties of both almost convex groups and rewriting systems for groups, and holds for all geodesically automatic groups. Closure properties for stackability are of interest, not only for providing more examples of classes of stackable groups, but also because some of the classes of groups that are stackable have restricted closure properties. This poster will present the current known information about the closure properties of stackable groups, as well as some other interesting examples of stackable groups. (Received August 17, 2012)

1086-20-364 **Carol Jacoby** (cjacoby@jacobyconsulting.com), Jacoby Consulting, Long Beach, CA, and **Peter Loth*** (lothp@sacredheart.edu), Department of Mathematics, Sacred Heart University, Fairfield, CT 06825. *Partial decomposition bases and Warfield groups.* Preliminary report.

We consider the class of abelian groups with partial decomposition bases. This class was developed by C. Jacoby in order to extend Barwise and Eklof's classification of torsion groups in $L_{\infty\omega}$ to Warfield groups. We prove that this class is the natural generalization of Warfield groups in $L_{\infty\omega}$ and that it is identical to the class of k -groups of Hill and Megibben, and, as such, closed under direct summands. (Received August 25, 2012)

1086-20-429 **Markus Lohrey*** (lohrey@informatik.uni-leipzig.de), University of Leipzig, Institut fuer Informatik, PF 100920, 04009 Leipzig, Germany. *Relating the compressed word problem and the word search problem.* Preliminary report.

Algorithms for compressed words have recently found applications in combinatorial group theory. For the compressed representation of words we use straight-line programs (SLPs). An SLP is a context-free grammar C that generates a unique string $\mathrm{val}(C)$. This allows for exponential compression. Fix a finitely generated (f.g.) group G with symmetric generating set A . The compressed word problem (CWP) for G asks, whether for a given SLP C with terminal alphabet A one has $\mathrm{val}(C) = 1$ in G . It is known that if G has a polynomial time CWP,

then every f.g. subgroup of $\text{Aut}(G)$ has a polynomial time (ordinary) word problem. For example, right-angled Artin groups, f.g. nilpotent groups, Coxeter groups, and fully residually free groups have polynomial time CWP's. Another computational problem that is important in our context is the word search problem (WSP). For a given word $w \in A^*$, the goal is to compute a Van Kampen diagram for w in case $w = 1$ in G . Automatic groups and f.g. nilpotent groups have polynomial time WSP's. Our main result states the following: Let $1 \rightarrow K \rightarrow G \rightarrow Q \rightarrow 1$ be a short exact sequence of f.g. groups such that K has a polynomial time CWP and Q has a polynomial time WSP. Then G has a polynomial time (ordinary) word problem. (Received September 01, 2012)

1086-20-471 **Marcus Bishop*** (marcus.bishop@rub.de). *Computations for Coxeter arrangements and Solomon's descent algebra.*

We discuss a refinement of a conjecture of Lehrer and Solomon expressing the characters of a finite Coxeter group W afforded by the homogeneous components of its Orlik-Solomon algebra as sums of characters induced from linear characters of centralizers of elements of W . Our refined conjecture also relates the Orlik-Solomon characters above to the terms of a decomposition of the regular character of W related to its descent algebra. A consequence of our conjecture is that both the regular character of W and the character of its Orlik-Solomon algebra have parallel, graded decompositions as sums of characters induced from linear characters of centralizers of elements of W , one for each conjugacy class of elements of W . The refined conjecture has been proved for symmetric and dihedral groups and in this talk we discuss the algorithmic tools we used to prove the conjecture computationally for the finite Coxeter groups of rank at most six. (Received September 04, 2012)

1086-20-640 **Bobbe Cooper** and **Eric Rowland***, LaCIM, Université du Québec à Montréal. *Distinguished equivalence classes of words in F_2 .*

A central theme in the study of equivalence classes of F_n under $\text{Aut } F_n$ is that information about the equivalence class of a word can be obtained from statistics of its contiguous subwords. In this spirit, we give a new characterization of words in F_2 of minimal length in their equivalence class. We then introduce a natural operation that grows words from smaller words by duplicating a letter. Although this operation does not have any obvious algebraic interpretation, it turns out to provide a refinement of the notion of a minimal-length word, and the "maximally minimal" words in F_2 comprise distinguished equivalence classes with restricted structure. Moreover, many equivalence classes can be obtained under the growth operation from the distinguished classes. (Received September 10, 2012)

1086-20-670 **Ellen M Ziliak***, eziliak@ben.edu. *Message Authentication Codes using Quasigroups.* Preliminary report.

Cryptography is the science of secure communication which is a very broad field. One widely studied cryptosystem that is used to protect message authenticity and data integrity is called a Message Authentication Code, or MAC. Usually MAC's are based on hash function, block ciphers and other algebraic structures. It turns out that cryptography is a great field to attract students into research in Abstract Algebra. In this talk I will discuss a project done with an undergraduate research student studying the security of a specific MAC. I will also discuss other applications that are interesting and accessible to undergraduates interested in applications of abstract algebra. (Received September 10, 2012)

1086-20-797 **Cristian Lenart**, **Satoshi Naito**, **Daisuke Sagaki** and **Anne Schilling*** (anne@math.ucdavis.edu), Department of Mathematics, University of California, One Shields Ave, Davis, CA 95616, and **Mark Shimozono**. *A uniform combinatorial model for Kirillov-Reshetikhin crystals and specialized Macdonald polynomials.* Preliminary report.

Our goal is to prove that $P_\lambda(q) = X_\lambda(q)$, where $P_\lambda(q)$ is the Macdonald polynomial $P_\lambda(q, t)$ specialized at $t = 0$ and $X_\lambda(q)$ is the graded character of a simple Lie algebra coming from tensor products of Kirillov-Reshetikhin (KR) modules. In pursuit of this goal, we present a new explicit formula for the X polynomials, by characterizing the previously inexplicit formula using projected Lakshmibai-Seshadri (LS) paths, in terms of the parabolic quantum Bruhat graph (a combinatorial device coming from quantum cohomology of homogeneous spaces). This is achieved by establishing a lifting of the projected LS paths to the level-0 weight poset, which was first introduced by Littelmann. We also show a generalization of results by Deodhar which involves the compatibility of the quantum Bruhat graph with the cosets for every parabolic subgroup of the Weyl group. This should be the key structure to establish $P = X$. (Received September 12, 2012)

1086-20-835 **Ronald Solomon*** (solomon.1@osu.edu) and **Andrew J. Woldar**. *Simple groups and commuting graphs.*

I will report on the proof of the theorem that a finite simple group S is determined up to isomorphism by the commuting graph on the set $S - Z(S)$; that is, if G is any finite group having commuting group (on $G - Z(G)$) isomorphic to that of S , then G is isomorphic to S . (Received September 13, 2012)

1086-20-844 **Leonard L. Scott*** (lls21@virginia.edu). *Some cohomology of finite and algebraic groups.*

This talk involves joint work with several authors, especially Brian Parshall and David Stewart. I will review the theory of “generic cohomology” and a new, sharper form of it called “shifted generic cohomology”. It focuses on cohomology with irreducible coefficients, and is defined for any algebraic group G . For a given Lie rank and cohomology degree m , with the exception of finitely many finite fields F , it computes the cohomology of the finite group of Lie type $G(F)$ with coefficients in any absolutely irreducible $G(F)$ module (over a field of the same characteristic as that of F) in terms of the cohomology of G with irreducible coefficients in a related irreducible rational G -module—for which stonger methods are available. Indeed, the older theory of “generic cohomology” already has striking applications to finite groups, when coupled with the algebraic groups theory surrounding the Lusztig conjecture and Kazhdan-Lusztig polynomials. As time permits, I will illustrate with some computer calculations of Frank Luebeck, confirmed by my undergraduate student Tim Sprowl, which, together with observations of Bob Guralnick, have overturned a 1961 conjecture on maximal subgroups of finite groups. (Received September 13, 2012)

1086-20-848 **Amanda A. Schaeffer Fry*** (mandi@math.arizona.edu), University of Arizona, Tucson, AZ 85721. *$Sp_6(2^a)$ is “Good” for the McKay, Alperin Weight, and Related Local-Global Conjectures.*

The so-called “local-global” conjectures in the representation theory of finite groups relate the representation theory of G to that of certain proper subgroups, such as the normalizers of particular p -groups. Recent results by several authors reduce some of these conjectures to showing that a finite set of stronger conditions hold for all finite simple groups. Here, we show that $G = Sp_6(2^a)$ is “good” for these reductions for the McKay conjecture, the Alperin weight conjecture, and their blockwise versions. (Received September 14, 2012)

1086-20-850 **Gabriel Navarro*** (gabriel.navarro@uv.es), Mathematics, Dr Moliner 50, 46100 Burjassot, Valencia, Spain. *Normality and Zeros of Characters of Finite Groups.*

In finite groups there seems to exist a connection between normality and certain subgroups of the group on which no irreducible complex character vanishes. We will explore and discuss some results which somehow illustrate this phenomenon. (Received September 14, 2012)

1086-20-866 **Stephen D Smith*** (smiths@math.uic.edu), Department of Mathematics (m/c 249), University of Illinois at Chicago, 851 S Morgan, Chicago, IL 60607-7045. *Involutions and the Steinberg module.* Preliminary report.

A result of Geoff Robinson (1988) about all finite groups shows that a mod-2 projective contains a vector fixed by an involution centralizer; and if the module is irreducible, the class of this involution is unique. In the special case of a Lie type group in characteristic 2 and the Steinberg module, a result of Gow (1988) shows this involution is the longest element w_0 of the Weyl group. However, this special case does not seem to have been established independently using the Lie theory. The talk will indicate some preliminary results in that direction. (Received September 14, 2012)

1086-20-1021 **Pedro A. García-Sánchez*** (pedro@ugr.es), Departamento de Álgebra, Facultad de Ciencias, Universidad de Granada, 18071 Granada, Granada, Spain, and **Micah J. Leamer**. *Huneke-Wiegand Conjecture for complete intersection numerical semigroup rings.*

If R is a one-dimensional integrally closed local domain and M is a finitely generated torsion-free R -module, then M is free if and only if $M \otimes_R \text{Hom}(M, R)$ is torsion-free. C. Huneke and R. Wiegand have conjectured that this property holds for all one-dimensional Gorenstein domains.

Conjecture *Let R be a one-dimensional Gorenstein domain and let $M \neq 0$ be a finitely generated R -module, which is not projective. Then $M \otimes_R \text{Hom}_R(M, R)$ has a non-trivial torsion submodule.*

We show that if Γ is a free numerical semigroup, then monomial ideals of the semigroup ring $k[\Gamma]$ satisfy the Huneke-Wiegand Conjecture. We also show that if $k[\Gamma]$ is complete intersection, then two-generated monomial

ideals of Γ satisfy the Huneke-Wiegand Conjecture. In order to prove this, we make extensive use of the concept of gluing.

First we prove that extensions of relative ideals behave well with respect to gluing. We also show that for every complete intersection numerical semigroup Γ and every $s \in \mathbb{N} \setminus \Gamma$ there is an arithmetic sequence $(x, x+s, x+2s)$ in Γ that does not factor as the sum of two shorter arithmetic sequences in Γ . (Received September 18, 2012)

1086-20-1022 **Joshua Wiscons*** (wiscons@math.uni-muenster.de). *Moufang sets of finite Morley rank with little projective groups of odd type.*

We present a pair of results that identify certain split 2-transitive permutation groups of finite Morley rank as $\mathrm{PSL}_2(K)$ for K an algebraically closed field. We cast the results in the language of Moufang sets where the focus is on those where either the root groups are solvable or the Hua subgroup is nilpotent. Additionally, we show how the results fit into the investigation of the Cherlin-Zil'ber conjecture: every infinite simple group of finite Morley rank is an algebraic group over an algebraically closed field. (Received September 18, 2012)

1086-20-1024 **Alfred Geroldinger*** (alfred.geroldinger@uni-graz.at), Institute for Mathematics and Scientific Comp, University of Graz, 8010 Graz, Austria. *Local and global tameness in Krull monoids.*

Let H be a Krull monoid with finite class group G , and let $u \in H$ be an atom (an irreducible element). The local tame degree $\mathbf{t}(H, u)$ is the smallest integer $N \in \mathbb{N}_0$ with the following property: for any multiple a of u and any factorization $a = v_1 \cdots v_n$ of a into atoms, there is a subproduct which is a multiple of u , say $v_1 \cdots v_m$, and a refactorization of this subproduct which contains u , say $v_1 \cdots v_m = uu_2 \cdots u_\ell$, such that $\max\{\ell, m\} \leq N$.

The local tame degree $\mathbf{t}(H, u)$ measures the distance between an arbitrary factorization of a and a factorization of a which contains u . So u is a prime element iff $\mathbf{t}(H, u) = 0$. The (global) tame degree $\mathbf{t}(H)$ is the supremum of the local tame degrees over all atoms $u \in H$. The finiteness of the class group easily implies that the finiteness of the tame degree.

We discuss upper and lower bounds for $\mathbf{t}(H)$, and the relationship between $\mathbf{t}(H)$ and the tame degree $\mathbf{t}(\mathcal{B}(G))$, where $\mathcal{B}(G)$ is the monoid of zero-sum sequences over the class group G .

Joint work with W. Gao and Wolfgang A. Schmid. (Received September 18, 2012)

1086-20-1051 **Wade Mattox*** (wade.mattox@salem.edu). *Homology of Group Von Neumann Algebras.*

This work investigates the connections between properties of groups G and properties of their group von Neumann algebras $N(G)$. In particular, the module-theoretic properties of $N(G)$ over the complex group ring are studied. It is conjectured that $N(G)$ is dimension-flat if and only if G is amenable, and this conjecture is still open. Relatedly, it is also conjectured that $N(G)$ is flat if and only if G is locally virtually cyclic. I have proved this result for a subclass of elementary amenable groups and various other special cases. The known results concerning these conjectures will be discussed, as well as the cases which are still unproven. (Received September 18, 2012)

1086-20-1207 **Markj Sapir*** (m.sapir@vanderbilt.edu), SC 1326, Department of Mathematics, Vanderbilt University, Nashville, TN 37240. *Aspherical groups and manifolds with extreme properties.*

We present the version of Higman embedding construction that preserves asphericity. (Received September 20, 2012)

1086-20-1238 **Bhama Srinivasan*** (srinivas@uic.edu), Department of Mathematics, University of Illinois at Chicago, 851 S.Morgan Street, Chicago, IL 60607. *The Heisenberg algebra and $GL(n, q)$.* Preliminary report.

B.Leclerd and J-Y.Thibon [Int.Math.Res.Notices 9 (1996), 447-456] have studied the action of an affine Lie algebra \widehat{sl}_e and of a Heisenberg algebra H_e on a Fock space with basis indexed by partitions of all non-negative n . We consider this basis as indexing the unipotent representations of $GL(n, q)$ for all non-negative n and study the action of H_e . In particular, Leclerd and Thibon introduced certain operators in H_e which, when applied to the basis vector indexed by the empty partition, give the highest weight vectors for the irreducible representations of \widehat{sl}_e on the Fock space. We show that these operators are related to Deligne-Lusztig operators. (Received September 20, 2012)

1086-20-1261 **Michael Hull*** (michael.b.hull@vanderbilt.edu). *Conjugacy Growth in Finitely Generated Groups.*

We will consider the conjugacy growth function of a finitely generated group G , which counts the number of conjugacy classes which non-trivially intersect the ball of radius n centered at the identity. We will study the similarities and differences between the conjugacy growth function and the ordinary growth function, and we

will show how to construct groups with interesting properties with respect to conjugacy growth. The main tool in these constructions will be the theory of small cancellation over relatively hyperbolic groups. This is joint work with Denis Osin. (Received September 20, 2012)

1086-20-1310 **John Huerta*** (john.huerta@anu.edu.au). *The categorified super-Poincaré group.*

We discuss categorifications of certain Lie groups, replacing the Lie group with a Lie groupoid satisfying the group axioms only weakly. Specifically, in spacetimes of dimension 3, 4, 6 or 10, there are two ways to categorify the super-Poincaré group, the supersymmetric analogue of the symmetry group of Minkowski spacetime. One begins with the canonical 3-form on the orthogonal group, the other begins with a 3-form on the translation part that is closed only in these dimensions. We can also combine the two. We discuss both of these categorifications, and how they play a role in string theory. (Received September 21, 2012)

1086-20-1400 **John D Hutchens*** (jdhutche@ncsu.edu), North Carolina State University, Box 8205, Raleigh, NC 27695. *k-involutions of Exceptional Linear Algebraic Groups.* Preliminary report.

Symmetric spaces have been studied for their role in Lie groups and algebraic groups. They can be defined as the homogeneous spaces G/K where G is a reductive algebraic group and K maximal compact subgroup, which is also the fixed point group of an involution. Generalizations of symmetric spaces arise in many areas and are often called symmetric k -varieties. A symmetric k -variety is defined as the quotient G_k/H_k , where G is an algebraic group defined over a field k , $H = G^\theta$ is the fixed point group of a k -involution θ of G and G_k and H_k are the k -rational points of G and H . For every isomorphism class of k -involutions we get an isomorphism class of symmetric k -varieties. These have been classified for some algebraic groups of types A , B , C , and D . In this talk we discuss some recent results about the classification of k -involutions for exceptional groups. (Received September 22, 2012)

1086-20-1413 **Nolan R. Wallach***, Department of Mathematics, University of California, San Diego, La Jolla, CA 92093, and **David Meyer**. *The (quantum) hidden subgroup problem for $ax+b$ groups.* Preliminary report.

If F is a finite field then we denote by $G(F)$ the group of affine transformations of F . Let $|F|$ be the order of F . We give an algorithm that solves the hidden subgroup problem with probability $1 - \varepsilon$ after $O(\log(\varepsilon)^2 \log |F|)$ repetitions that has the complexity of 3 multiplicative quantum Fourier transforms and 3 quantum additive Fourier transforms. The basic ingredient in the algorithm is the set of wavelets associated to the unique irreducible representation that is not one dimensional. The proof of the algorithm uses basic elementary number theory (such as the theory of Gauss sums). (Received September 21, 2012)

1086-20-1527 **Atefeh Mohajeri Moghaddam***, mohajeri@math.mcgill.ca, and **Olga Sharlampovich**. *Approximation of Geodesics in Metabelian Groups.*

It is known that the bounded Geodesic Length Problem in free metabelian groups is NP-complete, in particular the Geodesic Problem is NP-hard. We construct a 2-approximation polynomial time deterministic algorithm for the Geodesic Problem in free metabelian groups. We show that the Geodesic Problem in the restricted wreath product of a finitely generated non-trivial group with a finitely generated abelian group containing \mathbb{Z}^2 is NP-hard and there exists a Polynomial Time Approximation Scheme for this problem. We also show that the Geodesic Problem in the restricted wreath product of two finitely generated non-trivial abelian groups is NP-hard if and only if the second abelian group contains \mathbb{Z}^2 . (Received September 23, 2012)

1086-20-1552 **Michael Aschbacher***, Department of Mathematics, Caltech, Pasadena, CA 91125. *Overgroup lattices of reducible subgroups of classical groups.*

We show that if G is a finite classical group and H is a subgroup of G such that the overgroup lattice of H in G is in the class $D\Delta$ of Shalev, then (modulo an exceptional open case) H is irreducible on the defining space of G . (Received September 23, 2012)

1086-20-1599 **Alexander Ushakov***, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ 07030. *Algorithmic theory of free solvable groups: randomized computations.*

We devise new deterministic and randomized algorithms for algorithmic problems in free solvable groups. In particular, we prove that the word problem and the power problem can be solved in quasi-linear time by Monte-Carlo type algorithms. (Received September 23, 2012)

- 1086-20-1644 **H.E.A. Campbell, R. James Shank and David L. Wehlau*** (wehlau@rmc.ca), P.O. Box 17000 Stn Forces, Kingston, Ontario K7K 7B4, Canada. *Invariants of Certain Elementary Abelian p -groups.*

I will discuss the polynomial invariants of three dimensional representations of elementary abelian p -groups $(\mathbb{Z}/p\mathbb{Z})^r$ for $r = 1, 2, 3$. A moduli space for these representations and the rings of invariants of these groups will also be described. (Received September 23, 2012)

- 1086-20-1654 **Benjamin Steinberg*** (bsteinberg@ccny.cuny.edu), Department of Mathematics, City College of New York, 138 St at Convent Avenue, New York, NY 10463. *Synchronizing groups: a survey.* Preliminary report.

Synchronizing groups form a class of finite permutation groups lying between the class of primitive permutation groups and doubly transitive groups. They were first considered by the speaker in 2005, and then a year later by Joao Araujo. The original motivation came from Cerny's conjecture in automaton theory. However, interesting connections with combinatorics were found by Peter Neumann, Peter Cameron and others.

In this talk, we give a brief survey of this interesting subject. All results discussed are a subset of results by J. Araujo, P. Cameron, P. Neumann, C. Schneider, P. Spiga and the speaker. (Received September 23, 2012)

- 1086-20-1696 **Klaus M Lux*** (klux@math.arizona.edu). *The GAP package Basic 1.0.* Preliminary report.

We present the new version 1.0 of the GAP package Basic, which is joint work with T. Hoffman from Coastal Carolina University. Basic can be used to compute the structure of the projective indecomposable modules for a block of a group in finite characteristic and moreover the basic algebra of the block. Using Basic, we are currently compiling a database of basic algebras for blocks of simple groups of order less than a billion, which can be used for a further investigation of the blocks. We highlight some recent results, illustrate important applications, and discuss new algorithmic enhancements. Finally, we also indicate connections to the GAP packages QPA, Chop, Cond, and Ext. (Received September 24, 2012)

- 1086-20-1701 **Benjamin Fine*** (fine@fairfield.edu), **Anthony Gaglione, Gerhard Rosenberger and Dennis Spellman.** *Some Consequences of the Solution to the Tarski Problems.* Preliminary report.

From the positive solution to the Tarski problems by Kharlampovich and Myasnikov and independently Sela it follows that every first order theorem in a nonabelian free group is true in every elementary free group. An elementary free group is a group that shares the first order theory of the class of nonabelian free groups. The class of elementary free groups extends beyond the class of free groups and in particular includes the class orientable surface groups of genus $g \geq 2$. As a consequence Magnus' theorem concerning the normal closures of elements in free groups is true in surface groups. This was proved directly by J. Howie and independently by O. Bogopolski in a quite difficult manner. This type of result opens up several different types of questions. The first is which additional nontrivial free group results are true in surface groups but difficult to obtain directly. Secondly what first order properties of nonabelian free groups are true beyond the class of elementary free groups. (Received September 24, 2012)

- 1086-20-1760 **Gerard F. Helminck*** (g.f.helminck@uva.nl), KdV Institute University of Amsterdam, Science Park 904 1098 XH Amsterdam, 1098 XH Amsterdam, Netherlands, and **Aloysius G. Helminck.** *Orbits of parabolic k -subgroups on symmetric k -varieties.*

Symmetric k -varieties are homogeneous spaces $X_k := G_k^\theta \backslash G_k$. Here G is a reductive connected algebraic group defined over a field k , $\text{char}(k) \neq 2$, and G_k denotes the group of k -rational points of G . Further, θ is an automorphism of order two of G , defined over k , and G^θ is its fixed point group.

Orbits of parabolic k -subgroups on these varieties occur in various situations. Our motivating example comes from representation theory, where we choose k to be a local field. A central issue there is the decomposition of natural representations of G_k related to X_k into irreducible ones. The building blocks of these decompositions are families of intertwining operators from the C^∞ -vectors of induced representations from the k -points P_k of a parabolic k -subgroup to certain types of C^∞ -functions on X_k .

In this talk we present a number of structural results for the relevant parabolic k -subgroups that can be used at the actual construction of these intertwining operators. Besides that, we have for general k a description of the P_k -orbits on X_k . (Received September 24, 2012)

- 1086-20-1813 **David E. Peifer*** (dpeifer@unca.edu), Department of Mathematics, UNC Asheville, Asheville, NC 28804-8511. *One Hundred Years of Infinite Group Theory: The Legacy of Max Dehn.*

One hundred years ago, in 1912, Max Dehn published a pivotal paper in which he states the word problem, conjugacy problem, and isomorphism problems for groups given by presentations. In many ways it is that paper that marks the beginning of infinite group theory. Already in 1912, Dehn had made important connections between infinite groups, geometry, and decidability. In the 1912 paper, Dehn solved the conjugacy problem for the surface groups by using ideas from hyperbolic geometry. In this talk, I will briefly explain how Dehn's work has influenced recent ideas in geometric group theory, such as M. Gromov's hyperbolic groups and W. Thurston's automatic groups. (Received September 24, 2012)

- 1086-20-1835 **Arielle Fujiwara, Joseph Gibson, Matthew Jenssen, Daniel Montealegre and Vadim Ponomarenko*** (vadim123@gmail.com), Department of Mathematics and Statistics, San Diego State University, 5500 Campanile Dr., San Diego, CA 92182-7720, and **Ari Tenzer**. *Arithmetic of Congruence Monoids.*

A congruence monoid is a multiplicative submonoid of the naturals, whose elements happen to comprise one or more congruence classes modulo some integer. This generalizes arithmetic congruence monoids. We study the structure of nonunique factorization within these congruence monoids. (Received September 24, 2012)

- 1086-20-1941 **Elizabeth Wilcox*** (ewilcox@colgate.edu). *The Chermak-Delgado Lattice of a Finite Group.*

Let G be a finite group with H a subgroup of G . The Chermak-Delgado measure of H in G is $|H||C_G(H)|$. The collection of all subgroups with maximum Chermak-Delgado measure forms a lattice, referred to as the Chermak-Delgado lattice of G . This idea was introduced in 1989 by A. Chermak and A. Delgado in the context of finite simple groups, but was reintroduced by I. Martin Isaacs in his recent group theory textbook.

Despite its straightforward definition, the subgroups in the Chermak-Delgado lattice obey some surprising properties. For example, the members of this lattice are all subnormal in G . However, a group of order 32 presents the first example of a subgroup in the Chermak-Delgado lattice that is subnormal but not normal.

This talk will discuss recent efforts to describe the Chermak-Delgado lattice of various kinds of products of groups in terms of the factors, as well as efforts to understand the relationship between the Chermak-Delgado lattice and the structure of p -groups. (Received September 24, 2012)

- 1086-20-2001 **Mark B. Greer*** (mark.greer@du.edu), University of Denver-Mathematics, John Greene Hall, Room 203, 2360 S. Gaylord St, Denver, CO 80208. *Loops categorically isomorphic to Bruck loops.*

Given a uniquely 2-divisible group, we give a construction (originally used by Baer) for creating a new class of loops we call Γ -loops. Our main goal is showing a categorical isomorphism between uniquely 2-divisible Bruck loops and uniquely 2-divisible Γ -loops. Once this has been established, we can use the well known structure of Bruck loops of odd order to derive the Lagrange, Cauchy, Odd Order, Sylow and Hall theorems for Γ -loops of odd order, as well as the nilpotence of finite Γ - p -loops (p odd). In particular, this answers an open problem regarding the existence of Sylow p -subloops and Hall π -subloops in commutative automorphic loops. (Received September 24, 2012)

- 1086-20-2002 **Daniel Bragg and Nathaniel Thiem*** (thiemn@colorado.edu). *The representation theory of unipotent groups and a family of q -analogues to binomial coefficients.* Preliminary report.

Finite unipotent groups have notoriously difficult representation theories. For example, it remains undecided whether the number of irreducible representations of the maximal unipotent subgroups of the finite general linear group is polynomial in the size of the underlying field. However, by considering these groups as an infinite family and squinting a little, one obtains a rich Hopf structure which has a cornucopia of largely unexplored combinatorics. This talk will give some examples of combinatorial objects that naturally arise in this way, including a family of q -analogues to binomial coefficients that depend on finite posets. (Received September 24, 2012)

- 1086-20-2007 **Leah Childers*** (lchilders@pittstate.edu). *The Automorphism Group of the Hyperelliptic Torelli Group.*

The mapping class group is the group of orientation preserving homeomorphisms of a surface up to isotopy. A subgroup of the mapping class group of primary importance is the *Torelli group*, $\mathcal{I}(S_g)$, the kernel of the well-known symplectic representation of the mapping class group. We will discuss the structure of the *hyperelliptic*

Torelli group, $\mathcal{SI}(S_g)$. Elements of $\mathcal{SI}(S_g)$ act naturally on the symmetric separating curve complex, $C_{\mathcal{H}}(S)$. We will discuss that when $g \geq 5$, $\text{Aut}(C_{\mathcal{H}}(S_g)) \cong \text{SMod}^{\pm}(S_g)/\langle \iota \rangle$, where $\text{SMod}(S_g)$ is the symmetric mapping class group and ι is a fixed hyperelliptic involution. Then we will give an algebraic characterization of Dehn twists about symmetric separating curves which will allow us to conclude that $\text{Aut}(\mathcal{SI}(S_g)) \cong \text{SMod}^{\pm}(S_g)/\langle \iota \rangle$. Note that this work does not rely on a generating set for $\mathcal{SI}(S_g)$. (Received September 24, 2012)

1086-20-2034 **Tara C Davis*** (tdavis@hpu.edu), 1164 Bishop Street, UB210A, Honolulu, HI 96813, and **Alexander Yu. Olshanskii.** *Relative Subgroup Growth and Subgroup Distortion.* Preliminary report.

We study the connections between two asymptotic invariants of group embeddings, namely the relative growth of cyclic subgroups in finitely generated groups, and the corresponding distortion function of the embedding. In particular, when the distortion is non-recursive, the relative growth is at least almost quadratic. On the other hand, there exists a cyclic subgroup of a two generated group such that the distortion function associated to the embedding is not bounded above by any recursive function, and yet the relative growth is $o(r^2)$. (Received September 24, 2012)

1086-20-2048 **Yulan Qing*** (yulan.qing@tufts.edu), 503 Boston Ave., Medford, MA 02155. *Actions of Right Angled Coxeter Groups.* Preliminary report.

We define a CAT(0) cube complex that is a universal cover of a specific torus complex introduced by Croke and Kleiner. We prove that if an essential right-angled Coxeter group, one without central elements, acts cocompactly, properly discontinuously and by isometry on the the cube complex, then the local gluing geometry of the torus has to be right angle. We also prove further result about that existence of such an action forces strict visual decomposition of the group. (Received September 24, 2012)

1086-20-2094 **Bhama Srinivasan** and **C. Ryan Vinroot***, College of William and Mary, Department of Mathematics, P. O. Box 8795, Williamsburg, VA 23187. *Jordan decomposition and real-valued characters.*

Let \mathbf{G} be a connected reductive group defined over a finite field \mathbb{F}_q by Frobenius map F , and let $G = \mathbf{G}^F$. The Jordan decomposition of characters of G gives a correspondence between complex irreducible characters of G , and pairs (s, ψ) , where s is a semisimple element of the dual group G^* , and ψ is a unipotent character of the centralizer $C_{G^*}(s)$, which has certain invariance properties with respect to Deligne-Lusztig induction. If s is a real element of G^* , let $h \in G^*$ such that $hsh^{-1} = s^{-1}$, then given a unipotent character ψ of $C_{G^*}(s)$, the character ${}^h\psi$, defined by ${}^h\psi(x) = \psi(h^{-1}xh)$, is also a unipotent character of $C_{G^*}(s)$. We conjecture that an irreducible character of G corresponding to the pair (s, ψ) is real-valued if and only if s is a real element of G^* , and ${}^h\psi = \bar{\psi}$, where $hsh^{-1} = s^{-1}$. We give a proof of this conjecture in the case that \mathbf{G} has connected center and $C_{G^*}(s)$ is a Levi subgroup of G^* . (Received September 24, 2012)

1086-20-2199 **Adam M Glessner*** (aglessner@fullerton.edu). *Mackey functors and sharpness for fusion systems.* Preliminary report.

By recent work of Chermak, we can associate a classifying space—a topological construction that behaves, homotopically, like the p -completed classifying space of a finite group—to any saturated fusion system \mathcal{F} on a finite p -group S . There is a way of studying this classifying space of \mathcal{F} by gluing together classifying spaces BP , where P runs over the collection of subgroups of S that are \mathcal{F} -centric. For fusion systems of finite groups, i.e., for $\mathcal{F} = \mathcal{F}_S(G)$ with G a finite group containing S as a Sylow p -subgroup, this homological decomposition possesses a further feature called *sharpness*. Sharpness, which was studied and verified for the fusion system of a finite group by Dwyer, means that a certain spectral sequence arising from the above decomposition collapses onto the vertical axis. In other words, certain higher limits, arising naturally from this context, vanish. In this preliminary report, the authors explore sharpness for fusion systems, utilizing a fusion system analogue of Mackey functors. We conjecture that the higher limits vanish for all fusion systems, and prove the conjecture for p -groups of p -rank 2 for p odd. (Received September 25, 2012)

1086-20-2324 **Marcos Zyman*** (mzyman@bmcc.cuny.edu), Department of Mathematics, 199 Chambers St., New York, NY 10007. *Homomorphisms of general linear groups.* Preliminary report.

We study homomorphisms between general linear groups and explore the “size” of the coset space they give rise to. This is a question in group theory motivated by research done by Hualé Huang and Joseph Roitberg on the genus and SNT sets of connected covers of one-point unions of spheres. (Received September 25, 2012)

- 1086-20-2371 **Shannon Ezzat*** (shannon.ezzat@gmail.com). *Representation Growth Using a Constructive Method.*

Representation growth is a subfield of asymptotic group theory, in which groups are studied indirectly by studying analytic properties of sequences associated to these groups. In representation growth we are concerned with counting the number of complex irreducible representations of degree n as $n \rightarrow \infty$. This sequence is commonly studied by encoding these numbers as coefficients in a zeta function, called the representation zeta function.

In this talk we will discuss representation growth of finitely generated nilpotent groups. For a class of filiform groups of arbitrary nilpotency class we use a constructive method to determine the zeta functions associated to these groups; this calculation was not possible using the standard representation growth techniques, namely the Kirillov orbit method. (Received September 25, 2012)

- 1086-20-2381 **Oded Yacobi*** (yacobi@gmail.com), 33 Salem Ave., Toronto, Ontario M6H3C2, Canada, and **Joel Kamnitzer, Ben Webster** and **Alex Weekes**. *Yangians and quantizations of slices in the affine Grassmannian.*

We study slices to Schubert varieties in the affine grassmannian. These are natural objects from the point of view of geometric Satake - they correspond to weight spaces of irreducible representations. We describe a quantization of these slices using subquotients of certain quantum groups called Yangians, and discuss the connections with quantizations of symplectic varieties and categorical g -actions. Based on joint work with Kamnitzer, Webster, and Weekes. (Received September 25, 2012)

- 1086-20-2390 **A. Bishop*** (acbishop@ncsu.edu), acbishop@ncsu.edu, Raleigh, NC 27606, **B. Turner**, Raleigh, NC 27606, **N. Schwartz**, Raleigh, NC 27606, **J. Hutchens**, Raleigh, NC 27606, **C. Cyr**, Gainesville, FL 32603, and **S. Kamholtz**, Eugene, OR 97403. *On the Structure of Automorphisms and Symmetric Spaces of Dicyclic Groups.* Preliminary report.

We study the analogues of symmetric spaces for the family of dicyclic groups of order $4n$. We investigate the structure of the automorphism group, characterize the involutions of the automorphism group, and determine the fixed-point group and symmetric space of each automorphism. Moreover, we determine the structure of the orbits of the symmetric space when the group and fixed-point group act by twisted conjugation. Finally, we describe the isomorphism classes of automorphisms and involutions. (Received September 25, 2012)

- 1086-20-2392 **Owen Thomas Baker*** (obaker@math.mcmaster.ca), Department of Math & Stats, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada. *Cannon-Thurston Maps and Subgroup Distortion.*

If H and G are hyperbolic groups and $H \leq G$, then a continuous map $\partial H \rightarrow \partial G$ induced by the inclusion homomorphism is called a Cannon-Thurston map. It is unique if it exists. In this talk, I will discuss joint work with Tim Riley where we show that the Cannon-Thurston map fails to exist in some instances, answering a question of Mitra. Then I will discuss the effect of the complexity of the subgroup distortion on the quality of the Cannon-Thurston map, in cases where the map exists. (Received September 25, 2012)

- 1086-20-2457 **Efim Zelmanov*** (ezelmano@math.ucsd.edu), Dept of Mathematics, 9500 Gilman Drive, La Jolla, CA 92093 - 0112, USA, La Jolla, CA 92093. *Complexity of Groebner - Shirshov rewriting systems.*

We will discuss time complexity of Groebner-Shirshov rewriting systems for groups and semigroups presented by generators and relators. (Received September 25, 2012)

- 1086-20-2559 **David C. McKlveen** (mcklveend1343@my.uwstout.edu), 871 Mandalay Terrace, De Pere, WI 54115, and **Sharif Younes*** (syounes@bowdoin.edu), 294 Hayts Rd., Ithaca, NY 14850. *Length of Families of Elements in Thompson's Groups F and T .*

Thompson's groups F and T were introduced by Richard Thompson in the 1960's in connection with questions in logic. They have since found applications in many areas of mathematics including algebra, logic and topology. For F it is known how to calculate the word metric with respect to the so-called "consecutive" generating sets X_n , which has allowed researchers to analyze its metric properties such as almost convexity and dead ends with respect to these generating sets. For T , there is no generating set for which an algorithm is known for determining the word metric so its metric properties are less well known. We develop tools for determining the length with respect to the generating set $\{x_0, x_{-1}, c\}$ of elements whose diagram representations have a certain form, and we use these tools to determine the exact length of three infinite families of elements in T . (Received September 25, 2012)

- 1086-20-2583 **Nathan A Corwin*** (s-ncorwin1@math.unl.edu), Department of Mathematics, 203 Avery Hall, Lincoln, NE 68588. *A non-embedding result for Thompson's Group V*. Preliminary report.

Thompson's group V was first defined in 1965. It can be interpreted as a particular subgroup of the automorphism group of the Cantor set. We use some dynamical properties of the action of an element of V on the Cantor Set of to show that $\mathbb{Z} \wr \mathbb{Z}^2$ does not embed into Thompson's group V . This result adds to the limited number of structure theorems for V . Part of the interest in a dynamical approach stems from the historical difficulty of purely algebraic techniques to obtain structure results about V . (Received September 25, 2012)

- 1086-20-2660 **Carrie A. Whittle*** (cawhitt1@uark.edu), 1023 N. Shelly Ln., Republic, MO 65738. *The word problem in the automorphism groups of right-angled Artin groups is in P*. Preliminary report.

We construct a polynomial-time algorithm for the word problem in the automorphism groups of right-angled Artin groups. Our techniques generalize those of Schleimer where he finds a polynomial-time solution to the word problem for automorphism groups of free groups. (Received September 25, 2012)

- 1086-20-2735 **Margaret H. Dean*** (mdean@bmcc.cuny.edu), BMCC Math Department, 199 Chambers Street, New York, NY 10007. *The free metabelian product of free nilpotent groups*. Preliminary report.

In the variety of metabelian groups, it is known that the free product of two free abelian groups is residually torsion-free nilpotent. In a previously published result, I have shown that the metabelian free product of a free abelian group with a free nilpotent group of class 2 is residually torsion-free nilpotent. This talk encompasses preliminary results on the further investigation of metabelian free products and residual nilpotence; the next step is to look at the free metabelian product of free nilpotent groups with free nilpotent groups. (Received September 25, 2012)

22 ► Topological groups, Lie groups

- 1086-22-8 **We'am M. Jasim*** (s_weam@yahoo.com), Texas A & M International University, Department of Engineering, Mathematics, and, Physics LBV 312 5201 University Blvd, Laredo, TX 78041, and **robert r. kallman** (kallman@unt.edu), University of North Texas, Department of, Mathematics GAB 435, 1155 Union Circle #311430, Denton, TX 76203-5017. *Algebraically Determined Semidirect Products*.

Let G be a Polish (i.e., complete separable metric topological) group. Define G to be an algebraically determined Polish group if given any Polish group L and an algebraic isomorphism $\varphi : L \rightarrow G$, then φ is a topological isomorphism. The purpose of this paper is to prove a general theorem that gives useful sufficient conditions for a semidirect product of two Polish groups to be algebraically determined. This general theorem will provide a flowchart or recipe for proving that some special semidirect products are algebraically determined. For example, it may be used to prove that the natural semidirect product of H and G , where H is the additive group of a separable Hilbert space and G is a Polish group of unitaries on H acting transitively on the unit sphere with $-I \in G$, is algebraically determined. An example of such a G is the unitary group of a separable irreducible C^* -algebra with identity on H . Not all nontrivial semidirect products of Polish groups are algebraically determined, for it is known that the Heisenberg group is not an algebraically determined Polish group. (Received June 26, 2012)

- 1086-22-313 **Karl-Hermann Neeb** and **Hadi Salmasian*** (hsalmasi@uottawa.ca). *The Trotter property and differentiable vectors of continuous representations*.

Let (π, V) be a continuous representation of an infinite dimensional Lie group G . Under a mild condition on G which holds for the interesting examples, we show that the common domain of k -fold products of the (unbounded) operators $d\pi(x)$, for $x \in \text{Lie}(G)$, is equal to the space of C^k vectors in V . We give an application of this result to unitary representations of Lie supergroups. (Received August 20, 2012)

- 1086-22-544 **Neil Hindman*** (nhindman@aol.com), **Dona Strauss** and **Yevhen Zelenyuk**. *Longer chains of idempotents in βG* .

Given idempotents e and f in a semigroup, $e \leq f$ if and only if $e = fe = ef$. We show that if G is a countable discrete group, p is a right cancelable element of $G^* = \beta G \setminus G$, and λ is a countable ordinal, then there is a strictly decreasing chain $\langle q_\sigma \rangle_{\sigma < \lambda}$ of idempotents in C_p , the smallest compact subsemigroup of G^* with p as a member. We also show that if S is any infinite subsemigroup of a countable group, then any nonminimal

idempotent in S^* is the largest element of such a strictly decreasing chain of idempotents. (It had been an open question as to whether there was a strictly decreasing chain $\langle q_\sigma \rangle_{\sigma < \omega+1}$ in \mathbb{N}^* .) (Received September 06, 2012)

1086-22-643 **Monique A. Peters*** (momolove67@yahoo.com). *More differences between the right and left topological extensions of a semigroup operation to βS .* Preliminary report.

If S is a semigroup, the operation can be extended to its Stone-Čech compactification βS so that it becomes a right topological semigroup with S contained in its topological center. It can also be extended so that βS becomes a left topological semigroup. Denote by \cdot the first of these extensions and by \odot the second. If S is commutative, one simply gets that $p \cdot q = q \odot p$ for all $p, q \in \beta S$. In particular, the smallest two sided ideals are identical. Previous research has shown that if S is the free semigroup on 2 or countably many generators, the operations can be very different. In particular the smallest two sided ideals can be disjoint. In general βS contains a closed two sided ideal $J(S)$ with the following property: A subset A of S satisfies the conclusion of the Central Sets Theorem if and only if there is an idempotent in $J(S) \cap \text{cl}A$. We show that if S is the free semigroup on countably many generators, $J(S, \cdot)$ and $J(S, \odot)$ are not equal. (Received September 10, 2012)

1086-22-780 **Kourtney Fulton*** (kourtneyfulton@yahoo.com). *Chains of idempotents in the Stone-Čech compactification of free semigroups.* Preliminary report.

For $n \in \mathbb{N}$, let S_n be the free semigroup on the generators $\{a_1, a_2, \dots, a_n\}$ and let S_ω be the free semigroup on the generators $\{a_n : n \in \mathbb{N}\}$. We show that there exists a sequence $\langle q_n \rangle_{n=1}^\infty$ of idempotents in βS_ω such that for each n , q_n is minimal in βS_n and $q_{n+1} < q_n$ under the usual ordering of idempotents, where $q \leq p$ if and only if $q = pq = qp$. Given any finite subset F of $\{q_n : n \in \mathbb{N}\}$, there is a continuous homomorphism $\varphi : \beta S_\omega \rightarrow S_\omega^* = \beta S_\omega \setminus S_\omega$ such that $\varphi[\beta S_\omega] = F$. On the other hand, if $\tau : S_\omega \rightarrow \{q_n : n \in \mathbb{N}\}$ has infinite range, then the continuous extension $\tilde{\tau} : \beta S_\omega \rightarrow \beta S_\omega$ of τ cannot be a homomorphism. (Received September 12, 2012)

1086-22-1120 **Andrey Minchenko*** (an.minchenko@gmail.com), Einstein Institute of Mathematics, Edmond J. Safra Campus, Givat Ram, The Hebrew University of Jerusalem, 91904 Jerusalem, Israel. *Real semisimple subalgebras.*

The purpose of the talk will be to describe conjugacy classes of semisimple subalgebras of real semisimple Lie algebras. Namely, for a semisimple Lie algebra G , denote by $S(G)$ the set of conjugacy classes of semisimple subalgebras of G . Given a real semisimple Lie algebra G , complexification induces the map

$$\nu : S(G) \rightarrow S(G(\mathbb{C})).$$

I will describe the set $S(G(\mathbb{C}))$ and explain how to find fibers of ν . (Received September 19, 2012)

1086-22-1154 **Firas Y Hindeleh*** (hindelef@gvsu.edu), 1 Campus Dr., Allendale, MI 49426, and **Kermit L Sharp** (sharpkl@mail.gvsu.edu) and **Nick C Benthem**. *Low dimension Lie algebra dimension reduction by modding by the center.* Preliminary report.

We investigate reducing the order of real low dimensional Lie algebras by modding by the center. We find the isomorphism between the reduced algebra and one of the non-decomposable Lie algebras and explain why in certain cases the reduced algebra decomposes. (Received September 19, 2012)

1086-22-1175 **Lauren Kelly Williams*** (willia75@uwm.edu), Department of Mathematical Sciences, University of Wisconsin Milwaukee, P.O. Box 0413, Milwaukee, WI 53201. *Invariant polynomial functions on tensors under the action of a product of orthogonal groups.*

We exhibit a stable formula for the dimension of the invariant algebra of degree d homogeneous polynomial functions on $\otimes_{i=1}^r \mathbb{C}^{n_i}$ under the action of the product $O_{n_1} \times O_{n_2} \times \dots \times O_{n_r}$ of orthogonal groups. We provide formulas for these invariants, and establish a bijection between a basis for the invariants and the isomorphism classes of certain edge colored r -regular graphs. The dimension turns out to depend on the number of matchings that commute with a fixed permutation. We determine a formula for this number, and consider its combinatorial interpretations, such as a association to phylogenetic trees. (Received September 19, 2012)

1086-22-1401 **Sam Evens*** (sevens@nd.edu). *Limit Poisson structures and Richardson varieties.*

This talk is based on joint work with Arlo Caine. There is a well-known real algebraic Bruhat-Poisson structure π_{BP} on the flag variety G/B of a complex reductive group, whose symplectic leaves are Schubert cells. The Bruhat-Poisson structure is not invariant under the action of a maximal torus T of the Borel subgroup B , and we show that an appropriate limit of the torus action on the Bruhat-Poisson structure converges, and gives a torus invariant real algebraic Poisson structure on G/B whose symplectic leaves are intersections of Schubert cells with opposite Schubert cells. (Received September 21, 2012)

1086-22-1411 **Nolan R Wallach***, Department of Mathematics, University of California, San Diego, La Jolla, CA 92093. *On the GK dimension of a (\mathfrak{g}, K) module*. Preliminary report.

We study the Gelfand-Kirillov dimension of a (\mathfrak{g}, K) -module using the theory Jacquet modules. For example, we analyze the relative sizes of the discrete series representations. In particular, for a Hermitian pair the holomorphic or anti-holomorphic discrete series attain the unique minimum. If the pair is quaternionic then we show that if it is not also Hermitian then the quaternionic discrete series attain the unique minimum. One basic ingredient in the study is the analysis of irreducible (\mathfrak{g}, K) -modules as modules for enveloping algebras of unipotent subalgebras of \mathfrak{g} . Most of the results are known in other forms through the work of the Atlas group. The novel aspects of the work involve the module theoretic methods. (Received September 21, 2012)

1086-22-1448 **Mary Clair Thompson*** (mct0006@auburn.edu), 1355 Commerce Dr #408, Auburn, AL 36830, and **Tin-Yau Tam** (tamtiny@auburn.edu). *Convergence of the Bruhat Iteration*. Preliminary report.

Rutishauser's LR algorithm is extended in the context of a connected noncompact semisimple Lie group. We show that the sequence of iterates converges under certain conditions. (Received September 22, 2012)

1086-22-1531 **Daniel Bump***, Department of Mathematics, Stanford University, Stanford, CA 94305-2125. *Demazure operators, Whittaker functions and unique functionals*.

I will report on recent work of Brubaker, Bump and Licata and Brubaker, Bump and Friedberg on the use of Demazure-Lusztig operators to describe special functions (such as Whittaker functions) on reductive p-adic groups. I will touch on connections with crystal graphs and solvable lattice models. (Received September 23, 2012)

1086-22-1925 **Alireza Salehi Golsefidy*** (golsefidy@ucsd.edu). *Expansion properties of linear groups*. Starting with a finite (symmetric) subset Ω of $SL_n(\mathbb{Q})$, one can consider the group Γ generated by Ω and the Cayley graphs $\text{Cay}(\Omega, q)$ of $\pi_q(\Gamma)$ with respect to $\pi_q(\Omega)$, where π_q is the residue map modulo q . In this talk, I will address the following question that under what conditions $\{\text{Cay}(\Omega, q)\}$ forms a family of expander graphs as q runs through elements of various subsets of the positive integers. (Received September 24, 2012)

1086-22-2044 **Seung Won Lee*** (sw1006@math.ucsd.edu), Department of Mathematics, UC San Diego, 9500 Gilman Drive #0112, La Jolla, CA 92093. *Representations with Small K Types for Simply Connected, Simply Laced, Split Real Groups*.

Let G be the connected, simply connected split real form of simply laced, simple Lie type of rank ≥ 2 with a maximal compact subgroup K . We discuss a complete classification of "small" K types derived via Clifford algebras, and results on principal series admitting a small K type completely analogous to Kostant's results on spherical principal series. (Received September 24, 2012)

1086-22-2334 **Jeffrey Hakim*** (jhakim@american.edu), Department of Mathematics and Statistics, American University, Washington, DC 20016, and **Omer Offen**. *Local Converse Theorems for Distinguished Representations*. Preliminary report.

Let E/F be a quadratic extension of p-adic fields. Given a generic, unitary representation π of $GL(n, E)$, we consider when the triviality of the gamma factors of twists of π at the center of symmetry implies that π is distinguished with respect to $GL(n, F)$. (Received September 25, 2012)

1086-22-2474 **Jordan Alexander*** (jordan_alexander@baylor.edu), **Markus Hunziker** and **Jeb F. Willenbring**. *Hilbert series of determinantal varieties and strongly orthogonal roots*. Preliminary report.

The coordinate rings of the classical determinantal varieties (and their analogs for symmetric and skew-symmetric matrices) carry the structure of a unitary highest weight representation via Howe duality. We use this fact and a modified Enright-Willenbring correspondence between Wallach representations and certain finite dimensional representations to give a uniform formula for the numerator polynomials of the Hilbert series of all determinantal varieties. The key is a combinatorial phenomenon for Hermitian symmetric spaces. (Received September 25, 2012)

1086-22-2536 **Brandon Samples*** (brandon.samples@gcsu.edu), Georgia College & State University, Department of Mathematics, Campus Box 017, Milledgeville, GA 31061. *Components of Springer Fibers for the Exceptional Groups G_2 and F_4* .

Let G be the complex connected simply connected simple Lie group of type G_2 or F_4 . Let K denote the fixed point subgroup relative to an involution of G that is lifted from a Cartan involution. We give a description of certain components of Springer fibers associated to closed K -orbits contained in the flag variety of G . Then we

will describe certain multiplicity polynomials associated to discrete series representations of the real form G_2^2 of G_2 and the two real forms F_4^4 and F_4^{-20} of F_4 . The goals for this paper are motivated by the descriptions of Springer fiber components for type $SU(p, q)$ described in a paper of Barchini and Zierau. (Received September 25, 2012)

1086-22-2538 **Jennifer R. Daniel*** (jennifer.daniel@lamar.edu), Department of Mathematics, Campus Box 10047, Lamar University, Beaumont, TX 77710, and **Alys M. Rodriguez.** *Using a (σ, θ) -basis for the KAK decomposition in Quantum Computation.*

In quantum computation, new states evolve from initial states under a series of unitary transformations. The set of all unitary transformations form a Lie group called the unitary group $U(2^n)$. Without loss of generality, we only consider those unitary transformations in $SU(2^n)$ the Lie group of unitary matrices with determinant one. Decomposing arbitrary unitary transformations into the product of simple quantum gates is crucial to understanding the design of a quantum computer. One method of such decomposition utilizes consecutive Cartan decompositions into the ± 1 -eigenspaces \mathfrak{k} and \mathfrak{p} of an involutive automorphism θ of the Lie algebra $\mathfrak{su}(2^n)$. The Cartan decomposition induces a decomposition on the group level $SU(2^n) = KAK$, where $H = \exp(\mathfrak{a})$ for a maximal toral subalgebra \mathfrak{a} of \mathfrak{p} . Root space decomposition is utilized as a means of establishing a basis for \mathfrak{k} and \mathfrak{p} in the KAK decomposition. Once a basis is established, we can obtain a decomposition of any $U \in SU(2^n)$ into one qubit and controlled-not gates by exponentiating. (Received September 25, 2012)

1086-22-2837 **T. Christine Stevens*** (stevensc@slu.edu), Dept. of Mathematics and Computer Science, Ritter Hall 104, 220 N. Grand Blvd., St. Louis, MO 63103. *The dual groups of weakened group topologies for \mathbb{R}^n .*

We study the dual groups of a collection of metrizable group topologies for \mathbb{R}^n that are weaker than the usual topology. These topologies are defined by choosing a sequence $\{v_i\}$ in \mathbb{R}^n and specifying the approximate rate at which it converges to zero. If $\{v_i\}$ goes to infinity sufficiently fast in the usual topology, then such a group topology \mathcal{T} always exists. We prove that the group of continuous homomorphisms of $(\mathbb{R}^n, \mathcal{T})$ into the circle group is an uncountable subgroup of \mathbb{R}^n that is dense in \mathbb{R}^n in the usual topology, and its complement is also uncountable and dense. Since neither $(\mathbb{R}^n, \mathcal{T})$ nor its completion is locally compact, classical duality theory does not apply. (Received September 25, 2012)

26 ► Real functions

1086-26-74 **George A. Anastassiou*** (ganastss@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152. *Univariate Hardy type fractional inequalities.* Preliminary report.

Here we present integral inequalities for convex and increasing functions applied to products of functions. As applications we derive a wide range of fractional inequalities of Hardy type. They involve the left and right Riemann-Liouville fractional integrals and their generalizations, in particular the Hadamard fractional integrals. Also inequalities for left and right Riemann-Liouville, Caputo, Canavati and their generalizations fractional derivatives. These application inequalities are of $L_{-}\{p\}$ type, $p \geq 1$, and exponential type, as well as their mixture. (Received July 06, 2012)

1086-26-75 **George A. Anastassiou*** (ganastss@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152. *Fractional Integral Inequalities involving Convexity.* Preliminary report.

Here we present general integral inequalities involving convex and increasing functions applied to products of functions. As specific applications we derive a wide range of fractional inequalities of Hardy type. These involve the left and right: Erdélyi-Kober fractional integrals, mixed Riemann-Liouville fractional multiple integrals. Next we produce multivariate Poincaré type fractional inequalities involving left fractional radial derivatives of Canavati type, Riemann-Liouville and Caputo types. The exposed inequalities are of $L_{-}\{p\}$ type, $p \geq 1$, and exponential type. (Received July 06, 2012)

- 1086-26-105 **George A Anastassiou** (ganastss@memphis.edu), University of Memphis, 3725 Norriswood Avenue, Dunn Hall 200, Memphis, TN 38152, and **Razvan A Mezei*** (rmezei@lander.edu), Lander University, 320 Stanley Avenue, Laura Lander Hall 317, Greenwood, SC 29649. *Reverse and Forward Fractional Integral Inequalities*. Preliminary report.

Here we present reverse L_p fractional integral inequalities for left and right Riemann-Liouville, generalized Riemann-Liouville, Hadamard, Erdelyi-Kober and multivariate Riemann-Liouville fractional integrals. Then we derive reverse L_p fractional inequalities regarding the left Riemann-Liouville, the left and right Caputo and the left and right Canavati type fractional derivatives. We finish the article with general forward fractional integral inequalities regarding Erdelyi-Kober and multivariate Riemann-Liouville fractional integrals by involving convexity. (Received July 19, 2012)

- 1086-26-436 **Thomas Tyler Clark*** (tyler.clark@knights.ucf.edu), 1389 Northgate Circle, K107, Oviedo, FL 32765, and **Tom Richmond** (tom.richmond@wku.edu). *Continued Radicals and Cantor Sets*.

We will construct several continued radicals and look at their convergence properties. Furthermore, we will look at some conditions in which a continued radical creates a set homeomorphic to the cantor set. Finally, we will observe a continued radical formed by the set $\{1, 2\}$ and the thickness and measure of the cantor set obtained. (Received September 01, 2012)

- 1086-26-1047 **Javad Namazi*** (namazi@fdu.edu). *A Generalized Riesz transform*.

Let $T(f) = \sum_{n=0}^{\infty} (2n+d)P_n(f)$ be the spectral decomposition of $L^2(R^d)$, where $P_n(f) = \sum_{|\alpha|=n} \langle f, h_\alpha \rangle h_\alpha$ are the spectral projections with h_α being the multidimensional Hermite function in $L^2(R^d)$, and where α is a multi-index. We discuss some properties of T in $L^2(R^d)$ as well as in weighted spaces. (Received September 18, 2012)

- 1086-26-1219 **DoYong Kwon*** (doyong@jnu.ac.kr), Department of Mathematics, Chonnam National University, Gwangju, 500-757. *Moments of discrete measures with dense jumps induced by β -expansions*.

Let $\beta > 1$. Through an appeal to β -expansions we define a strictly increasing and left-continuous function μ_β on $[0, 1]$. Then μ_β turns out to be a pure jump distribution. In other words, its associated Lebesgue-Stieltjes measure is discrete, i.e., a summation of point masses. The present talk studies the moment of this discrete measure. We express the moment in terms of Bernoulli numbers and polylogarithms, and investigate its asymptotics as well. (Received September 20, 2012)

- 1086-26-1344 **J. Marshall Ash*** (mash@depaul.edu), Mathematics Department, DePaul University, Chicago, IL 60614. *Large convergent series and small divergent series*.

Say that the series $\sum a_n$ is *termwise much smaller* than $\sum b_n$ if $\lim_{n \rightarrow \infty} \frac{a_n}{b_n} = 0$, and $\sum a_n$ is *termwise much bigger* than $\sum b_n$ if $\lim_{n \rightarrow \infty} \frac{b_n}{a_n} = 0$. Given any series with terms tending to zero, there is a termwise much bigger convergent series. Given any conditionally convergent series, there is a termwise much smaller divergent series. (Received September 21, 2012)

- 1086-26-2162 **Kandasamy Muthuvel*** (muthuvel@uwosh.edu). *Weakly symmetric functions and weakly symmetrically continuous functions*. Preliminary report.

A function $f : \mathbb{R} \rightarrow \mathbb{R}$ is symmetrically continuous (resp. symmetric) at $x \in \mathbb{R}$, if $\lim_{n \rightarrow \infty} (f(x+h_n) - f(x-h_n)) = 0$ (resp. $\lim_{n \rightarrow \infty} (f(x+h_n) + f(x-h_n) - 2f(x)) = 0$) for every sequence $h_n \rightarrow 0$. The symbols $SC(f)$ and $S(f)$ denote the sets of points where f is symmetrically continuous and the set of points where f is symmetric, respectively. f is weakly symmetrically continuous (resp. weakly symmetric) at $x \in \mathbb{R}$, if there exists a sequence $h_n \rightarrow 0$ such that $\lim_{n \rightarrow \infty} (f(x+h_n) - f(x-h_n)) = 0$ (resp. $\lim_{n \rightarrow \infty} (f(x+h_n) + f(x-h_n) - 2f(x)) = 0$). The symbols $SC_w(f)$ and $S_w(f)$ denote the sets of points where f is weakly symmetrically continuous and the set of points where f is weakly symmetric, respectively. It is known that $SC_w(f) = \emptyset$ for some f and $S_w(f) = \emptyset$ for some f . In this talk we examine the set-theoretic difference of the above mentioned sets. (Received September 25, 2012)

- 1086-26-2760 **M. J. Sanders*** (mjsander@uscb.edu). *On the Closure of the Space of Substantially Darboux-like Honorary Baire Two Functions on \mathbb{R}^n* . Preliminary report.

A function $f : \mathbb{R}^n \rightarrow \mathbb{R}$ is said to be an *honorary Baire two function* if there exists a Baire one function $g : \mathbb{R}^n \rightarrow \mathbb{R}$ which agrees with f on a co-countable set. A function $f : \mathbb{R}^n \rightarrow \mathbb{R}$ is *substantially Darboux-like* if for each open connected set U in \mathbb{R}^n and for each $U \subset S \subset \bar{U}$ (the closure of U), $f(S)$ is an interval. On \mathbb{R} ,

the classes of Darboux and substantially Darboux-like functions are identical. Results regarding the closure of the space of substantially Darboux-like honorary Baire two functions are discussed. (Received September 25, 2012)

28 ► *Measure and integration*

1086-28-24 **Phanuel A Mariano*** (phanu9000@sbglobal.net), 120 Whitewood rd, Waterbury, CT 06708. *On the Coarse Geometry of L^p : A Coarse Equivalence.*

In recent years, coarse geometry has been on the spotlight because it was found to be useful in the progress of the Baum-Connes and Novikov conjectures. Coarse geometry deals with the large scale structure of a space as opposed to its small scale structure. This talk specifically studies the concept of a coarse equivalence of spaces regularly encountered in real analysis. We prove the existence of a non-separable space that is coarse equivalent to the separable space $L^1([a, b], m)$. (Received July 25, 2012)

1086-28-219 **Saroj Aryal** (saryal@uwyo.edu), University of Wyoming, Department of Mathematics, Laramie, WY 82071, **Farhad Jafari*** (fjafari@uwyo.edu), University of Wyoming, Department of Mathematics, Laramie, WY 82071, and **Mihai Putinar**, University of California at Santa Barbara, Department of Mathematics, Santa Barbara, CA 93106. *Sparse Moment Sequences.* Preliminary report.

The connection between continued fractions and moment sequences date back to the seminal work of Stieltjes. In the case of missing moment data, as it may be in the case of sparse moment sequences, the continued fractions will be significantly different from those associated with the original moment data. We have been studying the relationship between the asymptotic behavior of these continued fractions and the original continued fractions. (Received August 07, 2012)

1086-28-234 **Rolando de Santiago***, Cal Poly Pomona, 3801 W Temple Ave, Pomona, CA 91768, **Michel L. Lapidus**, University of California, Riverside, 900 University Ave, Riverside, CA 92521, **Scott A. Roby**, University of California, Riverside, 900 University Ave, Riverside, CA 92521, and **John A. Rock**, Cal Poly Pomona, 3801 W Temple Ave, Pomona, CA 91768. *Minkowski nonmeasurability of recursive strings.*

The class of generalized fractal strings called recursive strings have complex dimensions which exhibit a type of lattice structure. In this talk, we discuss the development of recursive strings and their complex dimensions as well as a criterion for Minkowski measurability in the context of ordinary fractal strings. In particular, this criterion reveals the fact that the boundary of an ordinary fractal string which is a recursive string is Minkowski nonmeasurable. (Received August 10, 2012)

1086-28-291 **Saroj Aryal*** (saryal@uwyo.edu), Mathematics Department, University of Wyoming, Laramie, WY 82070, **Farhad Jafari**, Mathematics Department, University of Wyoming, Laramie, WY 82070, and **Mihai Putinar**, Department of Mathematics, University of California at Santa Barbara, Santa Barbara, CA 93106. *Moment Sequences.* Preliminary report.

The well-known theorems of Stieltjes, Hamburger and Hausdorff establish conditions on infinite sequences of real numbers to be moment sequences. Further, works by Carathéodory, Schur and Nevanlinna connect moment problems to problems in function theory and functions belonging to various spaces. In many problems associated with realization of a signal or an image, data may be corrupted or missing. Reconstruction of a function from moment sequences with missing terms is an interesting problem leading to advances in image and/or signal reconstruction. It is easy to show that a subsequence of a moment sequence may not be a moment sequence. Conditions are obtained to show how rigid the space of sub-moment sequences is and necessary and sufficient conditions for a sequence to be a sub-moment sequence is established. A deep connection between the sub-moment measures and the moment measures is derived and the determinacy of the moment and sub-moment problems are related. This problem is further related to completion of positive Hankel matrices. (Received August 16, 2012)

- 1086-28-366 **Rolando de Santiago, Michel L. Lapidus, Scott A. Roby and John A. Rock***
(jarock@csupomona.edu), Department of Mathematics and Statistics, Cal Poly Pomona,
3801 W Temple Ave, Pomona, CA 91768. *Scaling multifractal spectra of self-similar
measures.*

The multifractal structure underlying a self-similar measure stems directly from the weighted self-similar system (or weighted iterated function system) which is used to construct the measure. This follows much in the way that the dimension of a self-similar set, be it the Hausdorff, Minkowski, or similarity dimension, is determined by the scaling ratios of the corresponding self-similar system via Moran's theorem. The multifractal structure of a self-similar measure allows for our definition of scaling regularity, scaling zeta functions, and scaling multifractal spectrum motivated by geometric zeta functions of fractal strings and, in particular, partition zeta functions of self-similar measures. In this talk, we discuss a key result regarding the abscissae of convergence of the scaling zeta functions of certain self-similar measures. In various cases, we recover the Moran equation associated with a given self-similar system, the Hausdorff multifractal spectrum, and the Hausdorff dimensions of Besicovitch subsets. (Received September 25, 2012)

- 1086-28-453 **David L. Skoug*** (dskoug@math.unl.edu), Department of Mathematics, 1144 T Street,
203 Avery Hall, Lincoln, NE 68588-0130. *Analytic Operator-Valued Feynman Integrals.*

Let $C_{a,b}[0, T]$ denote the general Wiener space where $a(t)$ is an absolutely continuous function on $[0, T]$ with $a(0) = 0$, $a'(t) \in L^2[0, T]$, and where $b(t)$ is a strictly increasing continuously differentiable function with $b(0) = 0$ and $b'(t) > 0$ for each $t \in [0, T]$. In this paper we study the operator-valued Feynman integral of functionals F on $C_{a,b}[0, T]$ of the form

$$F(x) = f\left(\int_0^T \theta_1(t) dx(t), \dots, \int_0^T \theta_n(t) dx(t)\right)$$

where $\int_0^T \theta_j(t) dx(t)$ denotes the PWZ stochastic integral and $\{\theta_1, \dots, \theta_n\}$ is an orthonormal set of functions of bounded variation in $L^2_{a,b}[0, T]$. (Received September 03, 2012)

- 1086-28-496 **Otis Chodosh, Vishesh Jain, Michael Lindsey*** (lindsey3@stanford.edu),
Lyuboslav Panchev and Yanir A. Rubinstein. *Visualizing optimal transportation
maps.* Preliminary report.

Given two sufficiently regular probability measures μ and ν on R^n , general results due to Brenier (1987) guarantee the existence and uniqueness of an optimal transportation map between them, that is a map $T : R^n \rightarrow R^n$ such that $T_{\#}\mu = \nu$ and the quadratic cost $\int_{R^n} |T(x) - x|^2 d\mu(x)$ is minimized. However, in general it is hard to say much about the map, let alone give an explicit expression for it. We present an efficient computer algorithm that uses a discretization of the problem to give perhaps the first pictures and movies of optimal transportation plans, for domains in R^2 . These suggest subtle relations between the geometry of the support of μ and ν and the regularity of T , some of which we are able to prove. (Received September 05, 2012)

- 1086-28-533 **Leobardo Rosales*** (lrosales@kias.re.kr), KIAS, 85 Hoegiro (Cheongnyangni-dong
207-43), Dongdaemun-gu, Seoul, 130-722, South Korea. *The Plateau Problem for the
c-Isoperimetric Mass of Currents.*

We introduce a new notion of mass for currents, generalized orientable immersions of Euclidean space, similar to the flat norm although with a scaling property. Through this mass, which we call the c -isoperimetric mass, we ask the analogous Plateau problem: this is classically, find a surface of least area spanning a given boundary curve in space. Questions of existence and regularity are studied and proposed. (Received September 06, 2012)

- 1086-28-700 **Byoung Soo Kim*** (mathkbs@seoultech.ac.kr), School of Liberal Arts, Seoul National
University of Science and Tech, Seoul, 139-743, South Korea, and **Bong Jin Kim**
(bjkim@daejin.ac.kr) and **Il Yoo** (iyoo@yonsei.ac.kr). *A change of scale formula for a
function space integral on $C_{a,b}[0, T]$.* Preliminary report.

Cameron and Storvick discovered change of scale formulas for Wiener integrals of functionals in a Banach algebra \mathcal{S} on classical Wiener space. Yoo and Skoug extended these results for functionals in the Fresnel class $\mathcal{F}(B)$ and in a generalized Fresnel class \mathcal{F}_{A_1, A_2} on abstract Wiener space. We establish a relationship between a function space integral and a generalized analytic Feynman integral on $C_{a,b}[0, T]$ for functionals in a Banach algebra $\mathcal{S}(L^2_{a,b}[0, T])$. Moreover we obtain a change of scale formula for a function space integral on $C_{a,b}[0, T]$ of these functionals. (Received September 11, 2012)

- 1086-28-930 **Jonas Azzam*** (jazzam@math.washington.edu), University of Washington, Department of Mathematics, C-138 Padelford, Seattle, WA 98195-4350. *Wasserstein Distance and Rectifiability of Doubling Measures.*

In a recent paper, Tolsa has characterized d -regular uniformly rectifiable measures in Euclidean space using Wasserstein distances. For a d -regular measure μ , he defines a quantity $\alpha(x, r)$ which, roughly speaking, measures the Wasserstein distance between μ inside the ball $B(x, r)$ and planar d -dimensional measure and proves that uniform rectifiability of μ is equivalent to $\alpha(x, r)^2 \frac{d\mu(x)dr}{r}$ being a Carleson measure. In this talk, we explore what conditions on $\alpha(x, r)$ are necessary to guarantee different grades of rectifiability for μ if we only assume μ is a doubling measure. We also establish rectifiability using more intrinsic quantities similar to $\alpha(x, r)$ involving the Wasserstein distance which estimate the doubling behavior of μ . (Received September 16, 2012)

- 1086-28-952 **Dong Hyun Cho*** (j94385@kyonggi.ac.kr), Department of Mathematics, Kyonggi University, Yountong-Gu, Suwon, Kyonggido 443-760, South Korea. *Relationships between the conditional Fourier-Feynman transform and convolution of unbounded functions on an analogue of wiener space.*

Let $C[0, t]$ denote the function space of all real-valued continuous paths on $[0, t]$. Define $X_n : C[0, t] \rightarrow \mathbb{R}^{n+1}$ and $X_{n+1} : C[0, t] \rightarrow \mathbb{R}^{n+2}$ by $X_n(x) = (x(t_0), x(t_1), \dots, x(t_n))$ and $X_{n+1}(x) = (x(t_0), x(t_1), \dots, x(t_n), x(t_{n+1}))$, where $0 = t_0 < t_1 < \dots < t_n < t_{n+1} = t$. In the present talk, using simple formulas for the conditional expectations with the conditioning functions X_n and X_{n+1} , we evaluate the $L_p(1 \leq p \leq \infty)$ -conditional analytic Fourier-Feynman transforms and the conditional convolution products of the functions which have the form

$$f_r((v_1, x), \dots, (v_r, x)) \int_{L_2[0, t]} \exp\{i(v, x)\} d\sigma(v)$$

for $x \in C[0, t]$, where $\{v_1, \dots, v_r\}$ is an orthonormal subset of $L_2[0, t]$, $f_r \in L_p(\mathbb{R}^r)(1 \leq p \leq \infty)$, and σ is the complex Borel measures of bounded variation on $L_2[0, t]$. We finally investigate several relationships between the conditional Fourier-Feynman transform and convolution of the functionals. (Received September 17, 2012)

- 1086-28-1686 **Stephen David Lewis*** (stedalew@uw.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-435. *The Geometry of Asymptotically Optimally Doubling Measures.*

A very general question in Geometric Measure Theory is “how does the regularity of a measure affect the geometry of its support?” An asymptotically optimally doubling measure on \mathbb{R}^n is one which infinitesimally behaves like m -dimensional Lebesgue measure. David, Kenig, and Toro, as well as Preiss, Tolsa, and Toro, studied such measures under a mild flatness assumption on the support. In this talk, we discuss the geometry of the support of such measures without any flatness assumptions. (Received September 24, 2012)

- 1086-28-1856 **Renee H Bell*** (rbell1916@berkeley.edu), **Ching Wei Ho** and **Robert S Strichartz**. *Energy Measures of Harmonic Functions on the Sierpinski Gasket.*

For a function u on the Sierpinski gasket, whenever its standard Laplacian Δu exists as a function, $\Delta(u^2)$ does not. The energy Laplacian defined through energy measures behaves better in this respect. We characterize the positive energy measures through studying the bounds of Radon-Nikodym derivatives with respect to the Kusuoka measure. We prove a limited continuity of the derivative on the graph V_* and express the average value of the derivative on a whole cell as a weighted average of the values on the boundary vertices. We also prove some characterizations and properties of the weights. (Received September 24, 2012)

- 1086-28-2180 **Robert Zbigniew Giza*** (rzgiza@gmail.com), 414 N. Reeder Ave., Covina, CA 91724. *Scaling zeta functions of partially-lattice weighted self-similar systems.* Preliminary report.

The α -scaling zeta function is the geometric zeta function of a fractal string given by a specific scaling regularity of a weighted self-similar system ($wsss$). For any $wsss$ it is known that the unique real-valued solution of Moran's equation is an upper bound for the abscissae of convergence of the α -scaling zeta functions. Also, in certain cases, the abscissae of convergence of the α -scaling zeta functions are the Hausdorff dimensions of the corresponding Besicovitch subsets. There still remains a large class of $wsss$ where the abscissae of convergence for the corresponding α -scaling zeta functions is unknown. The scope of this talk is concerned with the abscissae of convergence of a partially-lattice $wsss$. The main results derive multiplicities associated with the corresponding α -scaling zeta function in a much simpler format, and extract new bounds for the abscissae of convergence. (Received September 25, 2012)

- 1086-28-2614 **Ian Pierce*** (pierce@stolaf.edu), Department of Mathematics, St. Olaf College, 1520 St. Olaf Avenue, Northfield, MN 55057. *A Short Visit to Generalized Wiener Space.* Preliminary report.

Several talks that will be presented during this special session on “Interplays Between Feynman Operational Calculus, Wiener and Feynman Integrals, Physics, and Analysis on Wiener Space” make explicit (or implicit) reference to the notion of a generalized Wiener space. We will briefly introduce this concept and provide a few examples. This talk is intended to be expository in nature. No new results will be presented; rather our intent is to familiarize session attendees with the generalized Wiener measure and to briefly demonstrate possible connections between it and the subjects of some of the more technical talks given in this session. (Received September 25, 2012)

30 ► Functions of a complex variable

- 1086-30-65 **Rosihan M Ali*** (rosihan@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia, and **Yusuf Abu Muhanna**, Department of Mathematics, American University of Sharjah, Sharjah, United Arab Emirates. *Bohr’s phenomenon for analytic functions and the hyperbolic metric.*

A link is established between Bohr’s inequality for classes of analytic functions and the hyperbolic metric. The classes considered consist of analytic functions mapping the unit disk respectively into the right half-plane, the slit region, and to the exterior of the unit disk. (Received June 30, 2012)

- 1086-30-477 **Yunping Jiang*** (yunping.jiang@qc.cuny.edu), Department of Mathematics, Queens College of CUNY, 65-30 Kissena Blvd, Flushing, NY 11367. *Iterations on Teichmüller Spaces and the Characterization of Holomorphic Maps.*

This talk is based on my survey article “A FRAMEWORK TOWARDS UNDERSTANDING THE CHARACTERIZATION OF HOLOMORPHIC MAPS” for Milnor’s 80th birthday proceedings. In this talk, I will give a review of the work done by me with my collaborators, Cui, Zhang, Chen, Cheng, and Keen, on the characterization of geometrically finite rational maps and post-critically and post-singularly finite entire and meromorphic functions by using the iteration method on Teichmüller spaces. Then I will outline a framework for characterizing holomorphic maps. Whereas Thurston’s methods are based on estimates of hyperbolic distortion in hyperbolic geometry, the framework suggested here is based on controlling conformal distortion in spherical geometry. The new framework enables one to relax two of Thurston’s assumptions, first, that the iterated map has finite degree and, second, that its post-critical set is finite. Thus, it makes possible to characterize certain rational maps for which the post-critical set is not finite as well as certain classes of entire and meromorphic coverings for which the iterated map has infinite degree. (Received September 04, 2012)

- 1086-30-750 **Hagop Karakazian*** (mathproof@hotmail.com) and **Tamas Forgacs** (tforgacs@csufresno.edu), Department of Mathematics, 5245 North Backer Avenue, M/S PB108, Fresno, CA 93740. *On The Differential Operator Representation of Linear Operators Which Are Diagonal With Respect To Legendre Basis.* Preliminary report.

A linear operator $T : \mathbb{R}[x] \rightarrow \mathbb{R}[x]$ is said to be diagonal with respect to a basis $\mathcal{B} = \{b_n(x)\}_{n=0}^{\infty}$ if there exists a sequence of real numbers $\{\gamma_n\}_{n=0}^{\infty}$ such that $T[b_n(x)] = \gamma_n b_n(x)$ for every $n = 0, 1, 2, \dots$. In this talk we discuss the representation $T = \sum_{k=0}^{\infty} T_k(x) D^k$ of operators which are diagonal with respect to the Legendre basis. In particular, we present the form and some properties the coefficient polynomials $T_k(x)$ must have. (Received September 12, 2012)

- 1086-30-809 **Christopher M Judge*** (cjudge@indiana.edu), Department of Mathematics, Rawles Hall, Bloomington, IN 47401. *Holomorphic versus hyperbolic twisting.*

Near a point of the frontier of the moduli space of Riemann surfaces there are two well-known sets of ‘polar coordinates’. One is defined by the holomorphic structure and is determined by the ‘plumbing a node’ construction. The other is defined by the hyperbolic structure and is due to Fenchel and Nielsen. For a long time, it has been known that near the frontier, the ‘radial coordinates’ asymptotically agree. This work shows that the ‘angular’ coordinates also asymptotically agree. (Received September 13, 2012)

- 1086-30-825 **David J Pinchbeck*** (dpinchbe@sjcme.edu), 278 White’s Bridge Rd, Standish, ME 04084. *Schwarzian and Fuchsian equations on a Riemann surface.*

Let Ω be a Fuchsian connection on a rank-two holomorphic bundle on a punctured Riemann surface C , with associated matrix equation $F^{-1} \partial_z F = \Omega$. Let S be a projective connection on C with double poles, associated to

the scalar equation $y'' + (1/2)S(z)y = 0$. We describe a monodromy-preserving “Schwarzian operator” $\mathbf{S} : \Omega \mapsto S$; this mapping is bijective when restricted to spaces of connections with prescribed signatures at the punctures. We illustrate with an example in low genus. (Received September 13, 2012)

1086-30-855 **Constanze Liaw*** (constanze_liaw@baylor.edu), One Bear Place #97328, Waco, TX 76798, and **Catherine Beneteau, Alberto Condori, Daniel Seco and Alan Sola.** *Cyclicity and optimal approximants.*

We study cyclic functions f in the Dirichlet space. In particular, I will present recent results concerning the optimal approximating polynomials p_n which minimize the Dirichlet norm of the quantity $p_n f - 1$. (Received September 14, 2012)

1086-30-1001 **Lisa De De Castro*** (ldecastro@mail.usf.edu), Department of Mathematics & Statistics, University of South Florida, 4202 E Fowler Ave, CMC342, Tampa, FL 33620, and **Dmitry Khavinson.** *Analytic functions with real boundary values in Smirnov classes E^p .*

Let G be a finitely connected domain in the complex plane. The Smirnov class $E^p(G)$ and the Hardy class $H^p(G)$ are sets of analytic functions on G with prescribed growth conditions. When $p \geq 1$, a function of Smirnov class E^p can be recovered by its boundary values via the Cauchy integral. Functions in the Hardy classes can be recovered by their boundary values via the Poisson integral. If an analytic function of Hardy class has real boundary values, then it is a constant function. However, the same is not always true of functions in the Smirnov classes. This talk explores the geometric characteristics of G that will yield non-constant analytic functions in Smirnov classes $E^p(G)$ with real boundary values. (Received September 17, 2012)

1086-30-1018 **Subhojoy Gupta*** (sgupta@qgm.au.dk). *Half-plane differentials on Riemann surfaces.*

We shall discuss the existence of certain meromorphic quadratic differentials on Riemann surfaces with higher-order poles that arise in limits of Teichmüller rays. In the quadratic differential metric the surface is isometric to a collection of euclidean half-planes glued by an interval-exchange on their boundaries. (Received September 18, 2012)

1086-30-1137 **Holly Krieger*** (hkrieger@uic.edu). *Primitive prime divisors in the critical orbit of $z^d + c$.*

I will discuss the existence of primitive prime divisors of dynamical sequences defined over number fields, focusing on the forward orbit under $z^d + c$ of the critical point. Guaranteeing a primitive prime divisor for all but finitely many forward iterates is related to bounding the recurrence of the critical orbit, which can be done using arithmetic dynamics, Diophantine approximation, or by bounding recurrence in terms of the multiplier for parameters inside hyperbolic components of the Mandelbrot set, and I will touch upon each of these approaches. (Received September 19, 2012)

1086-30-1187 **Michael J Miller*** (millermj@lemoyne.edu), Dept of Mathematics, Le Moyne College, Syracuse, NY 13214. *A nonreal local extremum for the Sendov conjecture.* Preliminary report.

Let $S(n)$ be the set of all polynomials of degree n with all roots in the unit disk, and define $d(P)$ to be the maximum of the distances from each of the roots of a polynomial P to that root's nearest critical point. In this notation, Sendov's conjecture asserts that $d(P) \leq 1$ for every $P \in S(n)$.

Define $P \in S(n)$ to be *locally extremal* if $d(P) \geq d(Q)$ for all nearby $Q \in S(n)$, and note that identifying all locally extremal polynomials would settle the Sendov conjecture.

We have previously constructed real locally extremal polynomials of various degrees. In this paper, we construct a nonreal locally extremal polynomial of degree 9. (Received September 19, 2012)

1086-30-1233 **Tamas Forgacs*** (tforgacs@csufresno.edu) and **Andrzej Piotrowski.** *Reality of zeros of the coefficient polynomials of Hermite-diagonal operators.* Preliminary report.

Let $\{\gamma_k\}_{k=0}^\infty$ be a sequence of real numbers, let $\alpha > 0$ and let $T : \mathbb{R}[x] \rightarrow \mathbb{R}[x]$ be defined by $T[H_n^{(\alpha)}] = \gamma_n H_n^{(\alpha)}$ ($n = 0, 1, 2, \dots$), where $H_n^{(\alpha)}$ is the n th generalized Hermite polynomial. In this talk we show that in the representation $T = \sum T_k(x) D^k$ the T_k s must have only real zeros if $\{\gamma_k\}_{k=0}^\infty$ is an $H^{(\alpha)}$ -multiplier sequence. We also discuss results supporting the best possible converse: if the T_k s have only real zeros and $\{\gamma_k\}_{k=0}^\infty$ is a classical multiplier sequence, then it is in fact an $H^{(\alpha)}$ -multiplier sequence. (Received September 20, 2012)

- 1086-30-1566 **Mohammed A. Qazi*** (qazima@aol.com), Dept. of Mathematics, Tuskegee, AL 36088, and **Q. I. Rahman**. *An Extension of Bernstein's Inequality to Rational Functions*.

Let \mathcal{P}_n be the class of all polynomials of degree at most n . It is known that if $f \in \mathcal{P}_n$ and $|f(z)| \leq 1$ on the unit circle, then $|f'(z)| \leq |z|^{n-1}$ outside the unit disk. We present an extension of this result to rational functions which have all their poles in the open unit disk. (Received September 23, 2012)

- 1086-30-2698 **Stacey Muir*** (stacey.muir@scranton.edu), University of Scranton, Mathematics Department, Scranton, PA 18510, and **Michael Dorff**, Brigham Young University, Provo, UT. *A Family of Minimal Surfaces Constructed by Lifting Univalent Planar Harmonic Mappings*. Preliminary report.

We will present a family of minimal surfaces constructed by lifting a family of planar harmonic mappings. In the process, we will use the Clunie and Sheil-Small shear construction for planar harmonic mappings convex in one direction. As an example, we will examine a family of minimal surfaces that, through a continuous transformation, has connections with three well known surfaces: Enneper's surface, the wavy plane, and the helicoid. (Received September 25, 2012)

- 1086-30-2937 **Abi Komanduru*** (akomandu@purdue.edu), **Brett Ernst** and **Sean Fancher**. *Gravitational lensing by spiral galaxies*. Preliminary report.

Gravitational lensing is the bending of rays of light due to the presence of mass. One of the models used to describe the phenomenon of gravitational lensing (especially in astrophysics), the thin lens model, can be discussed using complex analysis. We state the basic assumptions and equations of this model. Then we consider a single source and examine the known solution of a planar elliptical mass distribution. Following that, we create a simplified model for a mass distribution resembling a spiral galaxy and present our derivation of the lensing equation for the simplified model. Finally we discuss potential research that would follow. (Received September 26, 2012)

31 ► Potential theory

- 1086-31-1017 **Wolfgang Keller*** (wolfgang.keller@gis.uni-stuttgart.de), Universität Stuttgart, Geodätisches Institut, 70174 Stuttgart, Germany. *The GRACE de-stripping problem. What does GRACE really see?*

The GRACE twin-satellite mission very successfully determines the monthly variations of the Earth's gravitational field. Nevertheless, the monthly solutions are severely disturbed by north-south stripe pattern, which makes the direct use of the monthly solutions impossible. Geophysically reasonable solutions can only be obtained after a smoothing, which considerably reduces the spatial resolution of the GRACE solutions.

The paper tries to find the cause of the generation of these vertical patterns and suggest possible counter-measures. (Received September 18, 2012)

- 1086-31-1190 **Alain Plattner**, Princeton, NJ 08544, and **Frederik J Simons*** (fjsimons@alum.mit.edu), Princeton, NJ 08544. *Spatiospectral concentration of vector fields on a sphere: Applications to satellite geomagnetism*.

We construct spherical vector bases that are bandlimited and spatially concentrated, suitable for the analysis and representation of real-valued vector fields on the surface of the unit sphere, as arises in the natural and biomedical sciences, and engineering. Building on the original approach of Slepian, Landau, and Pollak we concentrate the energy of our function bases into arbitrarily shaped regions of interest on the sphere and within a certain bandlimit in the vector spherical-harmonic domain. As with the concentration problem for scalar functions on the sphere, the vector basis can be constructed by solving a finite-dimensional algebraic eigenvalue problem. The eigenvalue problem decouples into separate problems for the radial, and tangential components. For regions with advanced symmetry such as latitudinal polar caps, the spectral concentration kernel matrix is very easily calculated and block-diagonal, which lends itself to efficient diagonalization. Like its scalar counterparts it should be a powerful tool in the inversion, approximation and extension of bandlimited fields on the sphere: vector fields such as gravity and magnetism in the earth and planetary sciences, or electromagnetic fields in optics, antenna theory and medical imaging. (Received September 19, 2012)

- 1086-31-1754 **Koushik Ramachandran*** (kramacha@math.purdue.edu). *Asymptotic behavior of positive harmonic functions in certain unbounded domains*.

We derive asymptotic estimates at infinity for positive harmonic functions in a large class of non-smooth unbounded domains. The latter include domains whose sections, after rescaling, resemble a Lipschitz cylinder or a Lipschitz cone, e.g., various paraboloids and horns. (Received September 24, 2012)

1086-31-2955 **Lucio Prado*** (lprado@bmcc.cuny.edu), 199 Chambers Street, New York, NY 10007.
p-Poisson Equations on Infinite Graphs and p-Capacity.

The discrete version of p-potential theory on Riemannian manifolds can be adapted to infinite/finite graphs G . With introduction of the concept of p-capacity on graphs, they can be classified on p-hyperbolic and p-parabolic. This talk will focus on p-hyperbolicity and the existence of solutions of p-Poisson equations $\Delta_p u + h = 0$ on the class of discrete p-Dirichlet functions of finite support $\mathcal{L}_0^{1,p}(V)$. In particular, if the time permits, related results for lattices and trees will be presented. (Received September 26, 2012)

32 ► Several complex variables and analytic spaces

1086-32-298 **Sofia Ortega Castillo*** (ortega@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, 77843-3368 College Station, TX, Mexico. *The cluster value problem in spaces of continuous functions.*

I will give an overview of some basic theory of Complex Analysis on Banach spaces, as well as I will present background on the two main problems I am interested in: the corona problem and the cluster value problem. I will also give an outline of the ideas and techniques involved in proving three cluster value theorems for spaces of continuous functions. This is joint work with William B. Johnson. (Received August 17, 2012)

1086-32-427 **Loredana Lanzani*** (loredana.lanzani@gmail.com), Mathematics Department, University of Arkansas, Fayetteville, AR 72701, and **Elias M. Stein**. *The Szego Projection for domains with minimal smoothness.* Preliminary report.

I will present recent joint work with E. M. Stein concerning the L^p -regularity problem for the Szego projection with respect to two distinct measures supported on the boundary of a strongly Levi-pseudoconvex domain of class C^2 . (Received September 01, 2012)

1086-32-462 **Mehmet Çelik*** (mehmet.celik@unt.edu), University of North Texas at Dallas, Department of Mathematics & Info. Sciences, 400 University Hills Blvd., Dallas, TX 75241, and **Sönmez Şahutoğlu**, University of Toledo, Department of Mathematics & Statistics, 2801 W. Bancroft, Toledo, OH 43606. *Compactness of the $\bar{\partial}$ -Neumann operator and of commutators of the Bergman projection with continuous functions.*

We show that on a bounded pseudoconvex domain compactness of the $\bar{\partial}$ -Neumann operator on square integrable forms is equivalent to compactness of commutator operators (of the Bergman projection with functions continuous on $\bar{\Omega}$) on square integrable $\bar{\partial}$ -closed forms. We also show that compactness of a commutator operator percolates up in the $\bar{\partial}$ -complex on $\bar{\partial}$ -closed forms and square integrable holomorphic forms. (This is a joint work with Sönmez Şahutoğlu.) (Received September 03, 2012)

1086-32-495 **Debraj Chakrabarti*** (debraj@math.tifrbng.res.in), Centre for Applicable Mathematics, Tata Institute of Fundamental Research, Sharadanagara, Chikkabommasandra, Bangalore, Karnataka 560 065, India, and **Kaushal Verma** (kverma@math.iisc.ernet.in), Department of Mathematics, Indian Institute of Science, Bangalore, Karnataka 560 012, India. *Condition R and holomorphic maps of piecewise smooth domains.*

We consider biholomorphic and proper maps between some classes of piecewise smooth domains and show that these maps extend smoothly up to the boundary. The domains considered include product domains, and domains in which the corners are generic CR manifolds. The source is assumed to satisfy Condition R, and the proof for the smooth case may be adapted to this situation. This leads to results of the Poincaré type on the biholomorphic inequivalence of classes of domains. (Received September 05, 2012)

1086-32-511 **Jim Agler** and **John E. McCarthy*** (mccarthy@math.wustl.edu). *Hankel vector moment sequences and the asymptotics of two variable Pick functions.*

A Pick function of d variables is a holomorphic map from Π^d to Π , where Π is the upper halfplane. Some Pick functions of one variable have an asymptotic expansion at infinity, a power series $\sum_{n=1}^{\infty} \rho_n z^{-n}$ with real numbers ρ_n that gives an asymptotic expansion on non-tangential approach regions to infinity. H. Hamburger in 1921 characterized which sequences $\{\rho_n\}$ can occur, in terms of an associated Hankel matrix. We shall discuss the analogous problem in two variables. (Received September 05, 2012)

1086-32-563 **Friedrich Haslinger*** (friedrich.haslinger@univie.ac.at), Fakultät fuer Mathematik, Nordbergstr. 15, A-1090 Vienna, Austria. *Spectral properties of the $\bar{\partial}$ -Neumann operator.*

We consider the $\bar{\partial}$ -Neumann operator

$$N : L^2_{(0,q)}(\Omega) \longrightarrow L^2_{(0,q)}(\Omega),$$

where $\Omega \subset \mathbb{C}^n$ is bounded pseudoconvex domain, and

$$N_\varphi : L^2_{(0,q)}(\Omega, e^{-\varphi}) \longrightarrow L^2_{(0,q)}(\Omega, e^{-\varphi}),$$

where $\Omega \subseteq \mathbb{C}^n$ is a pseudoconvex domain and φ is a plurisubharmonic weight function.

Using a general description of precompact subsets in L^2 -spaces we obtain a characterization of compactness of the $\bar{\partial}$ -Neumann operator, which can be applied to related questions about Schrödinger operators with magnetic field and Pauli and Dirac operators and to the complex Witten Laplacian.

In addition we discuss obstructions to compactness of the $\bar{\partial}$ -Neumann operator. (Received September 07, 2012)

1086-32-891 **Marco Abate*** (abate@dm.unipi.it), Dipartimento di Matematica, Università di Pisa, Largo Pontecorvo 5, 56017 Pisa, Pisa, Italy, **Jasmin Raissy** (jasmin.raissy@math.univ-toulouse.fr), Institut de Mathématiques de Toulouse, Université Paul Sabatier, 118 Route de Narbonne, 31062 Toulouse, France, and **Alberto Saracco** (alberto.saracco@unipr.it), Dipartimento di Matematica, Università di Parma, Parco Area delle Scienze 53/A, 43124 Parma, Italy. *Toeplitz operators and Carleson measures in strongly pseudoconvex domains.*

We study mapping properties of Toeplitz operators associated to a finite positive Borel measure on a bounded strongly pseudoconvex domain $D \subset \subset \mathbb{C}^n$. In particular, we give sharp conditions on the measure ensuring that the associated Toeplitz operator maps the Bergman space $A^p(D)$ into $A^r(D)$ with $r > p$, generalizing and making more precise results by Čučković and McNeal. To do so, we give a geometric characterization of Carleson measures and of vanishing Carleson measures of weighted Bergman spaces in terms of the intrinsic Kobayashi geometry of the domain, generalizing to this setting results obtained by Kaptanoğlu for the unit ball. (Received September 15, 2012)

1086-32-916 **Jane Gilman***, gilman@rutgers.edu. *Conformal Automorphism Groups, Adapted Bases, and Generating Vectors.*

Recently there has been renewed interest in the action of a conformal automorphism group on a compact Riemann surface as new more sophisticated group theoretic tools have been applied to the conformal, geometric, algebraic, and topological problem. I will summarize older results obtained when I originated the concept of an adapted homology bases for prime order automorphisms and extend these results and definitions to new results for arbitrary finite groups. I will use Broughton's more recent concept of a generating vector combined with the older methods of curve lifting-cutting-pasting and the less ad hoc method of Schreier-Reidemeister rewriting process and elimination of generators and relations. I will survey more recent results of Anderson, Wootton, Broughton, Buser, Gonzalez, Hildago, Weaver, Rodriguez and others. (Received September 16, 2012)

1086-32-1331 **Arash Karami*** (akarami@math.jhu.edu), 2735 Saint Paul Street, Art 5, Baltimore, MD 21218. *Zeros of random reinhardt polynomials in \mathbb{C}^{m+1} .*

For a Reinhardt domain Ω with the smooth boundary in \mathbb{C}^{m+1} and a positive smooth measure μ on the boundary of Ω , we consider the ensemble P_N of polynomials of degree N with the Gaussian probability measure γ_N which is induced by $L^2(\partial\Omega, d\mu)$. Our aim is to compute scaling limit distribution function and scaling limit pair correlation function between zeros when $z \in \partial\Omega$. First of all we apply stationary phase method to the Boutet de Monvel-Sjöstrand theorem to get the asymptotic for the partial szegő kernel, $S_N(z, z)$, and then we compute the scaling limit partial szegő kernel in any direction in \mathbb{C}^{m+1} , then by using the Kac-Rice formula we compute the scaling limit distribution function and scaling limit pair correlation function between zeros. (Received September 21, 2012)

1086-32-1601 **Vladimir Bolotnikov*** (vladi@math.wm.edu), Williamsburg, VA 23185-8795, and **Joseph A Ball** (joball@math.vt.edu), Blacksburg, VA 24061. *Shift-invariant subspaces, inner functions and related linear systems: the weighted Bergman space setting.*

Subspaces of the Hardy space of the unit disk which are invariant under the backward shift appear as the ranges of observability operators associated with a discrete-time-invariant linear system as well as the functional-model space for a Hilbert space contraction, while forward shift-invariant subspaces admit representations in terms of inner functions which can be written in terms of transfer-function realizations. Extensions of these results to the

multi-variable setting of the Druri-Arveson space are also known. In the talk, we will discuss several extensions to the setting of standard weighted Bergman spaces of the unit ball. (Received September 23, 2012)

1086-32-1743 **Jennifer Halfpap*** (halfpap@mso.unt.edu). *Understanding Projection Operators in Several Complex Variables through Harmonic Analysis.*

Operators such as the Bergman and Szegő projections are fundamental objects of study in several complex variables. In general, obtaining explicit expressions for the associated integral kernels is difficult. If, however, the domain under consideration is tube-like (hence preserved by certain translations), techniques from harmonic analysis lead to explicit expressions for these kernels. In this talk we outline this approach and discuss the kinds of results we have recently obtained with these techniques. (Received September 24, 2012)

1086-32-1787 **Emil J. Straube*** (straube@math.tamu.edu) and **Yunus Zeytuncu** (zeytuncu@math.tamu.edu). *Regularity of the complex Green operator on pseudoconvex CR-submanifolds of hypersurface type.* Preliminary report.

Using vector fields with good commutator properties with $\bar{\partial}$ has proved very successful in proving Sobolev estimates for the $\bar{\partial}$ -Neumann operator on pseudoconvex domains, and for the complex Green operator on pseudoconvex boundaries. We will discuss what can be done for CR-submanifolds of higher co-dimension, but still of hypersurface type. (Received September 24, 2012)

1086-32-1845 **Yunus E Zeytuncu*** (zeytuncu@math.tamu.edu), College Station, TX 77840. *Regularity of canonical operators and the Nebenhülle of Hartogs domains.*

Let \mathbb{D} denote the unit disk in \mathbb{C} and let $\phi(z)$ be a bounded subharmonic function on \mathbb{D} . We consider the pseudoconvex complete Hartogs domains in \mathbb{C}^2 of the form

$$\Omega = \{(z, w) \in \mathbb{C}^2 : z \in \mathbb{D} \text{ and } |w| < e^{-\phi(z)}\}.$$

Let N_1 denote the $\bar{\partial}$ -Neumann operator on $L^2_{(0,1)}(\Omega)$ and \mathbf{B}_Ω denote the Bergman projection on $L^2(\Omega)$. In this talk, we relate the regularity properties of N_1 and \mathbf{B}_Ω to the Nebenhülle of Ω and the Stein neighborhood bases of Ω . (Received September 24, 2012)

1086-32-1902 **Marco M. Peloso*** (marco.peloso@unimi.it), Dipartimento di Matematica, Via C. Saldini 50, Università degli Studi di Milano, 20133 Milano, Italy. *Function spaces on the complex sphere and regularity of solutions of dispersive equations.*

Consider the decomposition of $L^2(S^{2n-1})$ into eigenspaces for the sublaplacian on the sphere in \mathbb{C}^n .

In this talk we introduce some new spaces of functions on S^{2n-1} that measure smoothness of functions differently according to their spectral localization.

We study the boundedness of the sublaplacian spectral projections with respect to these norms.

We use this scale of spaces to study the regularity of solution of dispersive equations for the sublaplacian, for instance the Schrodinger and the wave equations.

This talk is based on joint work with V. Casarino. (Received September 24, 2012)

1086-32-1948 **Greg Knese*** (geknese@bama.ua.edu), University of Alabama, 145 Gordon Palmer Hall, Box 870350, Tuscaloosa, AL 35487-0350, and **Jeffrey S Geronimo** and **Plamen Iliev**. *Polynomials with no zeros on a face of the bidisk.* Preliminary report.

Geronimo and Woerdeman characterized when a positive bivariate trigonometric polynomial can be factored the square of a single stable polynomial (i.e. no zeros on the closed bidisk). The present work relaxes this stability condition to only require no zeros on a closed face of the bidisk. An interesting by product is a sum of squares formula for such polynomials. (Received September 24, 2012)

1086-32-2029 **Song-Ying Li*** (sli@math.uci.edu), Department of Math, RH 340, Irvine, CA 92617, and **Hyungwoon Koo** (koohw@korea.ac.kr), Department of Mathematics, Korea University, Seoul, 136-713, South Korea. *On Characterization of bounded composition operators.*

This is a joint work with Hyungwoon Koo. We provide some characterization theorems for the boundedness of composition operators on Hardy and weighted Bergman spaces over a strictly pseudoconvex domains in several complex variables. (Received September 24, 2012)

1086-32-2112 **David Scheinker*** (dscheink@gmail.com). *Regular and singular rational inner functions on the bidisc.* Preliminary report.

A rational inner function on the bidisc is called singular if it has singularities on the torus and regular if it does not. We differentiate between conditions for a Nevanlinna-Pick problem on the bidisc to have a unique solution that is a regular or a singular rational inner function. (Received September 24, 2012)

- 1086-32-2266 **Kevin Renna*** (kevin.renna@umontana.edu). *Using asymptotics to obtain sharp size estimates for a class of exponential integrals.*

Many problems in pure and applied mathematics involve the analysis of functions defined by integrals (e.g. Fourier and Laplace transforms). Of course, these technically-complicated integrals often resist or defy closed-form evaluation. Thus, we seek approximation techniques that give both size estimates and information about the error; this is the content of asymptotics. In this talk, we discuss basic asymptotics techniques and how they can be applied to a certain class of exponential integrals arising naturally in the study of several complex variables. (Received September 25, 2012)

- 1086-32-2699 **Hidetaka Hamada**, Kyushu Sangyo University, **Gabriela Kohr**, Babeş-Bolyai University, and **Jerry R. Muir, Jr.*** (jerry.muir@scranton.edu), Department of Mathematics, University of Scranton, Scranton, PA 18510. *Extensions of L^d -Loewner Chains to Higher Dimensions.*

Recently, there has been a great deal of research activity involving the theory of L^d -Loewner chains on the Euclidean unit ball \mathbb{B}_n of \mathbb{C}^n . For $d \in [1, \infty]$, these are families $\{f_t\}_{t \geq 0}$ of biholomorphic mappings from \mathbb{B}_n into \mathbb{C}^n such that $f_s(\mathbb{B}_n) \subseteq f_t(\mathbb{B}_n)$ for all $t \geq s \geq 0$ and, for each compact set $K \subseteq \mathbb{B}_n$ and $T > 0$, there is a nonnegative function $\kappa = \kappa_{K,T} \in L^d([0, T])$ such that

$$\|f_t(z) - f_s(z)\| \leq \int_s^t \kappa(x) dx, \quad z \in K, \quad 0 \leq s \leq t \leq T.$$

Classical normalized Loewner chains, families $\{f_t\}_{t \geq 0}$ of biholomorphic mappings satisfying $f_t(0) = 0$, $Df_t(0) = e^t I$ (I the identity operator), and $f_s \prec f_t$ (subordination) for all $t \geq s \geq 0$, are all L^∞ -Loewner chains. Certain extension operators, such as those due to Roper and Suffridge, Pfaltzgraff and Suffridge, and the speaker, extend normalized Loewner chains from lower to higher dimensions, and, consequently, these operators preserve certain geometric properties of mappings, such as starlikeness of the range. We consider whether the same extension results hold for general L^d -Loewner chains. (Received September 25, 2012)

33 ► *Special functions*

- 1086-33-43 **Jae-Ho Lee*** (jhlee@math.wisc.edu), Dept of Mathematics, University of Wisconsin-Madison, 480 Lincoln Dr., Madison, WI 53706. *Q -polynomial distance-regular graphs and the double affine Hecke algebra of type (C_1^\vee, C_1) .*

Let Γ denote a Q -polynomial distance-regular graph with vertex set X . We assume that Γ has q -Racah type and contains a Delsarte clique C . Fix a vertex $x \in C$. We partition X according to the path-length distance to both x and C . This is an equitable partition. For each cell in this partition, consider the corresponding characteristic vector. These characteristic vectors form a basis for a \mathbb{C} -vector space W .

The universal double affine Hecke algebra of type (C_1^\vee, C_1) is the \mathbb{C} -algebra \hat{H}_q defined by generators $\{t_n^{\pm 1}\}_{n=0}^3$ and relations (i) $t_n t_n^{-1} = t_n^{-1} t_n = 1$; (ii) $t_n + t_n^{-1}$ is central; (iii) $t_0 t_1 t_2 t_3 = q^{-1/2}$. We display an \hat{H}_q -module structure for W . For this module and up to affine transformation,

- $t_0 t_1 + (t_0 t_1)^{-1}$ acts as the adjacency matrix of Γ ;
- $t_3 t_0 + (t_3 t_0)^{-1}$ acts as the dual adjacency matrix of Γ with respect to C ;
- $t_1 t_2 + (t_1 t_2)^{-1}$ acts as the dual adjacency matrix of Γ with respect to x .

(Received June 20, 2012)

- 1086-33-191 **Nalini Joshi*** (nalini.joshi@sydney.edu.au), School of Mathematics and Statistics F07, University of Sydney, 2006, Australia. *Quicksilver solutions of a q -discrete Painlevé equation.*

Critical solutions of the classical Painlevé equations arise as universal limits in many nonlinear systems. Their asymptotic properties have been studied from several different points of view. This talk focusses on their discrete versions, for which many questions remain open.

Much of the activity in this field has been concentrated on deducing the correct discrete versions of the Painlevé equations, finding transformations and other algebraic properties and describing solutions that can be expressed in terms of earlier known functions, such as q -hypergeometric functions.

In this talk, I focus on solutions that cannot be expressed in terms of earlier known functions. In particular, I will describe solutions of the so called $q - P_{\text{III}}$ equation, which is a q -discrete version of the third Painlevé equation. The solutions I will describe are analogous to the critical or the tritronquée solutions, but their complex analytic properties differ. For this reason, I propose a new name: *quicksilver* solutions and provide a glimpse into their asymptotic properties. (Received August 05, 2012)

- 1086-33-337 **A. Sri Ranga*** (ranga@ibilce.unesp.br), DMap, IBILCE, Universidade Estadual Paulista, S.J. do Rio Preto, SP, 15054-000, Brazil. *A Favard type theorem associated with orthogonal polynomials on the unit circle.* Preliminary report.

The Favard Theorem for orthogonal polynomials on the unit circle (OPUC), also known as Verblunsky Theorem, can be stated as follows. Given an arbitrary sequence of complex numbers $\{\alpha_n\}_{n=0}^\infty$, where $|\alpha_n| < 1$, $n \geq 0$, then associated with this sequence there exists a unique nontrivial probability measure μ on the unit circle such that the polynomials $\{S_n\}$ generated by

$$S_n(z) = zS_{n-1}(z) - \bar{\alpha}_{n-1} S_{n-1}^*(z), \quad n \geq 1,$$

are the respective monic OPUC. In this talk we consider a Favard type theorem for OPUC starting from the three term recurrence formula

$$R_{n+1}(z) = [(1 + ic_{n+1})z + (1 - ic_{n+1})]R_n(z) - 4d_{n+1}zR_{n-1}(z), \quad n \geq 1,$$

with $R_0(z) = 1$ and $R_1(z) = (1 + ic_1)z + (1 - ic_1)$, where $\{c_n\}_{n=1}^\infty$ is any sequence of real numbers and $\{d_n\}_{n=1}^\infty$ is any positive chain sequence. Use of the theory of continued fractions plays an important role in this talk. (Received August 22, 2012)

- 1086-33-388 **Christian Berg*** (berg@math.ku.dk), Department of Mathematical Sciences, Universitetsparken 5, DK-2100 Copenhagen, Denmark. *On an iteration leading to a q -analogue of the Digamma function.*

We show that the q -Digamma function ψ_q for $0 < q < 1$ appears in an iteration studied by Berg and Durán. This is connected with the determination of the probability measure ν_q on the unit interval with moments $1/\sum_{k=1}^{n+1}(1-q)/(1-q^k)$, which are q -analogues of the reciprocals of the harmonic numbers. The Mellin transform of the measure ν_q can be expressed in terms of the q -Digamma function. It is shown that ν_q has a continuous density on $]0, 1]$, which is piecewise C^∞ with kinks at the powers of q . The talk is based on a joint manuscript with Helle B. Petersen posted in ArXiv:1111.0250. (Received August 28, 2012)

- 1086-33-394 **Ryu Sasaki*** (ryu@yukawa.kyoto-u.ac.jp), Kitashirakawa Oiwakecho, Sakyo-ku, Kyoto, 606-8502, Japan. *Multi-indexed q -Racah and Askey-Wilson polynomials.*

Multi-indexed orthogonal polynomials satisfy second order differential (difference) equations. They start at degree $\ell \geq 1$ and form a complete set of orthogonal functions. They are obtained by deforming the classical orthogonal polynomials (e.g. Jacobi, q -Racah, Askey-Wilson etc) in terms of multiple Darboux-Crum transformations and their difference analogues [1,2,3]. In the case of Jacobi, they form global solutions of Fuchsian differential equations having $3 + \ell$ regular singularities [1]. Multi-indexed q -Racah and Racah polynomials and their reductions provide ample examples of exactly solvable birth and death processes [4].

[1] S. Odake and R. Sasaki, "Exactly solvable quantum mechanics and infinite families of multi-indexed orthogonal polynomials," Phys. Lett. B **702** (2011) 164-170, arXiv:1105.0508[math-ph].

[2] S. Odake and R. Sasaki, "Multi-indexed (q)-racah polynomials, J. Phys. A **45** (2012) in press, arXiv:1203.5868[math-ph].

[3] S. Odake and R. Sasaki, "Multi-indexed Wilson and Askey-Wilson Polynomials," arXiv:1207.5584[math-ph].

[4] R. Sasaki, "Exactly Solvable Birth and Death Processes," J. Math. Phys. **50** (2009) 103509 (18 pp), arXiv:0903.3097[math-ph]. (Received August 29, 2012)

- 1086-33-540 **James McLaughlin*** (jmclaughlin2@wcupa.edu), Math. Dept., West Chester University, 25 University Avenue, West Chester, PA 19383. *Certain general Double-Sum Identities and variations of WP-Bailey Chains.*

We consider a number of general double-sum identities and their implications. These double-sum identities, when restricted in a certain way, lead to various new Bailey-type transforms. These new Bailey-type transforms in turn lead us to consider some variations/extensions of WP-Bailey chains of Andrews and others, which in turn lead to new basic hypergeometric identities and new proofs of some existing identities. (Received September 06, 2012)

- 1086-33-587 **Mizan Rahman*** (mrahman@math.carleton.ca), Colonel By Dr., Ottawa, ON. K1S 5B6, Canada, Ottawa, Ontario K1S 5B6, Canada. *A Koornwinder-type addition formula for parameter-free q -Racah polynomials.*

We give an elementary derivation of the product formula for the 4-parameter q -Racah polynomials, then use this formula to obtain an addition formula similar to Koornwinder's addition formula for the little q -Legendre polynomials. We also indicate how to extend this formula to the nonterminating case. (Received September 07, 2012)

- 1086-33-629 **Jasper V. Stokman*** (j.v.stokman@uva.nl), Korteweg-de Vries Institute for Mathematics, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, Netherlands. *Jackson integral solutions of reflection quantum Knizhnik-Zamolodchikov equations*. Preliminary report.

Two decades ago Reshetikhin extended the algebraic Bethe ansatz method to produce solutions of quantum Knizhnik-Zamolodchikov equations as Jackson integrals of weighted Bethe vectors. In this talk I present the extension of this result for Cherednik's reflection quantum Knizhnik-Zamolodchikov equations. I also explain how the simplest solution relates to Bailey's summation formula for very-well-poised ${}_6\Psi_6$ series. This talk is based on joint work with Nicolai Reshetikhin and Bart Vlaar. (Received September 09, 2012)

- 1086-33-753 **Luc Vinet*** (luc.vinet@umontreal.ca), Centre de Recherches Mathématiques, Université de Montréal, C.P. 6128, Succursale Centre-ville, Montréal, Québec H3C 3J7, Canada. *The Bannai-Ito Scheme*.

The classification of association schemes led Bannai and Ito to introduce a family of hypergeometric orthogonal polynomials that arise as a $q \rightarrow -1$ limit of the q -Racah polynomials. They were recently shown to be bispectral and to obey a difference equation of first order in Dunkl shifts. More polynomials with similar properties have been found lately. The purpose of this talk is to present the tableau that is emerging.

This is based on joint work with Alexei Zhedanov. (Received September 12, 2012)

- 1086-33-1645 **Michael J Schlosser*** (michael.schlosser@univie.ac.at), Department of Mathematics, University of Vienna, Nordbergstrasse 15, A-1090 Vienna, Austria. *Transformations for multivariate basic hypergeometric series by linearization*.

We apply linearization formulae for families of orthogonal polynomials to deduce transformations for univariate and multivariate basic hypergeometric series. The method we utilize is simple: Products of several orthogonal polynomials are linearized by repeated application of linearization of a product of two orthogonal polynomials. For products of more than two polynomials this can be done in different ways (more precisely, in different order), after which taking coefficients transformation formulae are obtained. A particular nice example involves the continuous q -ultraspherical polynomials. Linearization of the product of three such polynomials in two different ways yields a non-trivial very-well-poised ${}_{14}\phi_{13}$ transformation formula which first appeared, by different means, in work of R. Langer, S. O. Warnaar and the author (SIGMA, 2009). (Received September 23, 2012)

- 1086-33-2042 **Weilin Li***, 516 University Ave, Apt B4, Ithaca, NY 14850, and **Robert S Strichartz**. *Boundary Value Problems on a Half Sierpinski Gasket*.

This paper studies the fractal analogue of classical half-space boundary value problems for harmonic functions. We give the explicit formula for continuous solutions and the formula for the unique solution which extends continuously to the boundary. This unique continuous solution has well behaved properties, such as a simple energy estimate and an invertible Dirichlet to Neumann map. Finally, we give sufficient conditions for extending harmonic functions on the half space to biharmonic functions on the whole space and a partial converse to the extension conditions. (Received September 24, 2012)

- 1086-33-2082 **Daniel Joseph Galiffa*** (djg34@psu.edu), School of Science, 4205 College Drive, Erie, PA 16563. *Characterizing the General Sheffer Orthogonal Polynomial Sequences*. Preliminary report.

The presenter recently published the research monograph "On the Higher-Order Sheffer Orthogonal Polynomial Sequences" in the Springer Briefs in Mathematics series. The first part of this work rigorously describes the analysis that I.M. Sheffer utilized in characterizing all of the A-Type 0 orthogonal polynomials, i.e. the Sheffer Sequences, J. Meixner's approach to the same characterization problem as Sheffer, extensions to such characterizations by E.D. Rainville and W.A. Al-Salam and related results as well.

The second part of this work discusses several of the applications of the Sheffer Sequences, including differential equations, difference equations, quantum mechanics and numerical integration. Finally, the novel work of the monograph describes and implements a method for analyzing the Sheffer A-Type 1 class and discusses how this method can be used to analyze other higher-order Sheffer classes and similar characterization problems as well. In this talk, we show how the aforementioned monograph lends itself to determining all of the general Sheffer A-Type k orthogonal sets and connects this problem to a work completed by W.A. Al-Salam that may not be well-known to non-experts. (Received September 24, 2012)

1086-33-2169 **A Bathi Kasturiarachi*** (akasturi@kent.edu), Department of Mathematics, Kent State University at Stark, North Canton, OH 44720. *The Theory of Fractional Derivatives.*

In this paper we will outline the development of fractional derivatives. By studying fractional integrals and fractional derivatives we will examine the theory of fractional calculus. Historical notes, some new results, and applications will be presented. (Received September 24, 2012)

1086-33-2288 **Xiang-Sheng Wang*** (xswang@mun.ca), Dept of Math & Stat, Memorial University of Newfoundland, St. John's, NL A1C 5S7, Canada. *Uniform Asymptotics of Some q -Orthogonal Polynomials.* Preliminary report.

Uniform asymptotic formulas are obtained for the Stieltjes-Wigert polynomial, the q^{-1} -Hermite polynomial and the q -Laguerre polynomial as the degree of the polynomial tends to infinity. In these formulas, the q -Airy polynomial, defined by truncating the q -Airy function, plays a significant role. While the standard Airy function, used frequently in the uniform asymptotic formulas for classical orthogonal polynomials, behaves like the exponential function on one side and the trigonometric functions on the other side of an extreme zero, the q -Airy polynomial behaves like the q -Airy function on one side and the q -Theta function on the other side. The last two special functions are involved in the local asymptotic formulas of the q -orthogonal polynomials. It seems therefore reasonable to expect that the q -Airy polynomial will play an important role in the asymptotic theory of the q -orthogonal polynomials. (Received September 25, 2012)

34 ► Ordinary differential equations

1086-34-83 **Xueying Wang*** (xueying@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77840, and **Jay R. Walton, Rana D. Parshad, Katie Storey and May Boggess.** *Analysis of the Trojan Y-Chromosome eradication strategy for an invasive species.*

The Trojan Y-Chromosome (TYC) strategy has been proposed to eliminate invasive alien species. In this work, we analyze the dynamical system model of the TYC strategy, with the aim of studying the viability of the TYC eradication and control strategy of an invasive species. In particular, because the constant introduction of sex-reversed trojan females for all time is not possible in practice, there arises the question: What happens if this injection is stopped after some time? Can the invasive species recover? To answer that question, we perform a rigorous bifurcation analysis and study the basin of attraction of the recovery state and the extinction state in both the full model and a certain reduced model. In particular, we find a theoretical condition for the eradication strategy to work. Additionally, an Allee effect and a Turing instability are also studied in this work. Our results show that: (1) with the inclusion of an Allee effect, the number of the invasive females is not required to be very low when the introduction of the sex-reversed trojan females is stopped, and the remaining Trojan Y-chromosome population is sufficient to induce extinction of the invasive females; (2) incorporating diffusive spatial spread does not produce a Turing instability. (Received July 09, 2012)

1086-34-99 **Robert R. Ferdinand*** (rferdand@ecok.edu), **Jayson Bucy** (rferdand@ecok.edu), **Jeff Spears** (rferdand@ecok.edu), **Tomas Tillery** (rferdand@ecok.edu) and **Nick Nottingham** (rferdand@ecok.edu). *M.I.T.C.H - Medicinal Interaction 'Twixt' Cancer and Healthy Cells.*

A nonlinear, coupled system of three ordinary differential equations is presented. This system models the dynamics among healthy cells, cancer (tumor) cells and medicine in a living organism. Equilibrium points of this system are calculated and stability/non-stability criteria for the same are established. Results are illustrated graphically. *Mathematica software is used extensively in obtaining analytical and graphical results. Note: This research was conducted among a mathematics faculty and four undergraduate mathematics majors. It was funded by a Center for Undergraduate Research in Mathematics (CURM) mini-grant from NSF and BYU.* (Received July 19, 2012)

1086-34-121 **'Kale Oyedeji*** (koyedeji@morehouse.edu), Department of Physics, Morehouse College, Atlanta, GA 30314-3773. *Determination of Approximate Solutions to Non-linear Oscillatory Differential Equations.*

There has been much interest in solving non-linear differential equations which describe the oscillatory motion of systems which may be represented by differential equations of the form

$$\ddot{x} + g(x) = \varepsilon f(x, \dot{x}), \quad 0 < \varepsilon < 1,$$

where $g(x)$ and $f(x, \dot{x})$ are odd functions. In general, this equation cannot be solved exactly and therefore methods must be devised to construct analytical approximations to the solutions. The issue then is to determine which procedures may be used to construct valid methods which will allow the determination of these analytical approximations. A technique combining the method of first-order averaging and iteration is presented. This technique is based on transforming from a cartesian coordinate representation to one involving polar coordinates [1]. The procedure is illustrated by applying it to a number of specific differential equations having oscillatory solutions.

Reference

[1] Ronald E. Mickens and 'Kale Oyediji, Comments on the general dynamics of the nonlinear oscillator $\ddot{x} + (1 + \dot{x}^2)x = 0$, *Journal of Sound and Vibration* **330** (2011) 4196-4200. (Received July 25, 2012)

1086-34-181 **Nadir Ali Benkaci** (radians_2005@yahoo.fr), Faculty of Sciences, University of M'Hmed Bouguerra, Boumerdes, Algeria, **Abdelhamid Benmezai** (abenmezai@yahoo.fr), Faculty of Mathematics, USTHB, P.O. Box 32, Dynamical Systems Laboratory, El-Alia Bab-ezouar, Algiers, Algeria, and **Johnny Henderson*** (johnny_henderson@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798-7328. *Existence of a positive solution to a three point ϕ -Laplacian boundary value problem via homotopic deformation.*

Under suitable conditions and via a homotopic deformation, we provide existence results for a positive solution to the three point ϕ -Laplacian boundary value problem, $-(a\phi(u'))'(x) = b(x)f(x, u(x))$, $x \in (0, 1)$, $u(0) = \alpha u(\eta)$, $u'(1) = 0$, where $\phi : \mathbb{R} \rightarrow \mathbb{R}$ is an increasing homeomorphism with $\phi(0) = 0$, $\alpha, \eta \in [0, 1]$, $a, b \in C([0, 1], [0, +\infty))$, $a > 0$ in $[0, 1]$, b does not vanish identically, and $f : [0, 1] \times [0, +\infty) \rightarrow [0, +\infty)$ is continuous. (Received August 03, 2012)

1086-34-206 **Jean Marie Marie Linhart*** (jmlinhart@math.tamu.edu), Department of Mathematics MS 3368, Texas A&M University, College Station, TX 77843, and **Frances G. Withrow** (frances.withrow@gmail.com), 2020 Turning Leaf Drive, Bryan, TX 77807. *Can Humanity Survive? Mathematical Modeling of the Zombie Apocalypse.* Preliminary report.

The original paper on When Zombies Attack [1] provided a mathematical context for modeling the Zombie Apocalypse using the SIR (Susceptible-Infectious-Removed) ordinary differential equation model from epidemiological modeling. We question and change the assumptions in their model to be more realistic. We will show how ideas such as a sphere of influence (saturation) can help humanity survive a Zombie outbreak.

[1] P. Munz, I. Hudea, J. Imad and R. Smith?, 2009, When Zombies Attack, *Infectious Disease Modelling Research Progress*, p. 133-150. (Received August 07, 2012)

1086-34-213 **John R. Graef*** (john-graef@utc.edu), Department of Mathematics, University of Tennessee at Chattanooga, Chattanooga, TN 37403, and **Lingju Kong, Qingkai Kong and Min Wang.** *Uniqueness and parameter dependence of positive solutions to a higher order boundary value problem with fractional q -derivatives.*

We study the boundary value problem with fractional q -derivatives

$$\begin{aligned} -(D_q^\nu u)(t) &= \lambda f(t, u), \quad t \in (0, 1), \\ (D_q^i u)(0) &= 0, \quad i = 0, \dots, n-2, \quad (D_q u)(1) = \sum_{j=1}^m a_j (D_q u)(t_j), \end{aligned}$$

where $q \in (0, 1)$, $m \geq 1$ and $n \geq 2$ are integers, $n-1 < \nu \leq n$, $\lambda > 0$ is a parameter, $f : [0, 1] \times [0, \infty) \rightarrow [0, \infty)$ is continuous, $a_i \geq 0$ and $t_i \in (0, 1)$ for $i = 1, \dots, m$, and D_q^ν is the q -derivative of Riemann-Liouville type of order ν . The existence, uniqueness, and dependence of positive solutions on the parameter λ are discussed. Two sequences are constructed so that they converge uniformly to the unique solution of the problems. One example is included in the paper. Numerical computations of the example confirm our theoretical results. Recent results in the literature are extended and improved. (Received August 07, 2012)

1086-34-278 **Tre Wells*** (tre-wells@yahoo.com), Morehouse College, Atlanta, GA 30314, and **Ronald E Mickens** (rmickens@cau.edu), Clark Atlanta University, Atlanta, GA 30314. *An Exact Solution to the Linear Plus One-third Amplitude Damping Problem.*

Consider the following linear harmonic oscillator with nonlinear damping

$$\ddot{x} + x = -\varepsilon[a_1 \dot{x} + a_2 (\dot{x})^{\frac{1}{3}}], \quad x(0) = A, \quad \dot{x}(0) = 0,$$

where the parameter ε satisfies, $0 < \varepsilon \ll 1$, and a_1 and a_2 are non-negative; and the initial state has amplitude A , with zero velocity. We use the method of first-order averaging to calculate an approximation to the oscillatory

solution and show, by means of the explicit solution, that the amplitude of the damped oscillations go to zero in a finite time. This result holds true if the nonlinear damping term is replaced by $[\text{sgn}(\dot{x})]|\dot{x}|^\alpha$, where $0 < \alpha < 1$. (Received August 15, 2012)

1086-34-280 **Ronald E Mickens*** (rmickens@cau.edu), Clark Atlanta University, Atlanta, GA 30314, and **Tre Wells** (tre-wells@yayoo.com), Morehouse College, Atlanta, GA 30314.
Damping/Dissipative Forces having Finite-Time Dynamics.

In the mathematical modeling of mechanical systems, the damping and/or dissipative forces are generally represented as linear combinations of the velocity raised to positive integer values. (The velocity is taken as first derivative, with respect to time, of the dependent variable.) A major issue with such functional forms is that the associated system amplitude(s) go to zero only after an infinite time interval. However, this is not what is observed for actual systems. Using an explicit example, we show that there exists damping/dissipative forces for which the system dynamics ends in a finite time after the initial motion begins. We also discuss general functional forms for damping/dissipative forces and how they may be applied to the oscillations of carbon nano-tubes and graphene sheets. (Received August 15, 2012)

1086-34-281 **Sandra A Rucker*** (srucker@cau.edu), Clark Atlanta University, Atlanta, GA 30314.
Properties of the Leah-Cosine (Lcn) Function.

The Leah-cosine (Lcn) function is defined to be the solution to the following initial-value problem:

$$\ddot{x} + x^{\frac{1}{3}} = 0; \quad x(0) = 1, \quad \dot{x}(0) = 0.$$

Using phase-space and related techniques, we calculate the exact period (T) in terms of the Beta function, and also determine the area of the closed phase-space trajectories. We also derive the first terms of the Taylor expansion and provide arguments which show that this series converges in $(-\frac{T}{4}, \frac{T}{4})$. Finally, using the concepts of "cosine- and sine-like functions", an associated Leah-sine function is defined, along with a number of functional relations connecting quadratic powers of Lcn and Lsn to linear powers, but with altered arguments in their independent variables. (Received August 15, 2012)

1086-34-369 **Douglas R. Anderson*** (andersod@cord.edu), 901 Eighth Street S., Department of Mathematics, Moorhead, MN 56562. *First-order nonlinear nonlocal boundary value problem with p -Laplacian.*

Conditions for the existence of at least three positive solutions to the first-order nonlinear p -Laplacian problem with a nonlinear nonlocal boundary condition given by

$$[\phi_p(y)]'(t) - r(t)[\phi_p(y)](t) = \sum_{i=1}^m f_i(t, y(t)), \quad t \in [0, 1],$$

$$\lambda[\phi_p(y)](0) = [\phi_p(y)](1) + \sum_{j=1}^n \Lambda_j(\tau_j, [\phi_p(y)](\tau_j)), \quad \tau_j \in [0, 1],$$

are discussed, for sufficiently large $\lambda > 1$ and $r \geq 0$. The Leggett-Williams fixed point theorem is utilized. (Received August 26, 2012)

1086-34-558 **David Lipshutz*** (dlipshut@math.ucsd.edu), Department of Mathematics, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92092, and **Ruth J. Williams** (williams@stochastics.ucsd.edu), Department of Mathematics, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92092. *On Slowly Oscillating Periodic Solutions of Delay Differential Equations with Non-negativity Constraints.*

Dynamical system models with delayed feedback, state constraints and small noise arise in a variety of applications in science and engineering. Under certain conditions oscillatory behavior has been observed. Here we consider a prototypical fluid model approximation for such a system — a one-dimensional delay differential equation with non-negativity constraints. We explore conditions for the existence and stability of slowly oscillating periodic solutions of such equations. We illustrate our findings with simple examples from internet rate control and gene regulation. (Received September 06, 2012)

- 1086-34-626 **Dilbaj Singh*** (dilbaj.singh@lpu.co.in), Department of Mathematics, Lovely Professional University, Jalandhar - Delhi G.T. Road (NH-1), Phagwara, Punjab 144411, India, and **Dr. Sanjay Kumar Srivastava** (srivastava_bcet@yahoo.com), Department of Mathematics, Beant College of Engineering and Technology, Gurdaspur, Punjab 143521, India. *Stability of Impulsive Functional Differential Equations.*

In this paper, the notion of eventual stability for impulsive functional differential equations is investigated. The sufficient conditions that are obtained significantly depend on the moments of impulses. Our technique depends on Liapunov's direct method. (Received September 09, 2012)

- 1086-34-699 **G., Edgar Parker*** (parkerge@guilford.edu), Department of Mathematics, Guilford College, Greensboro, NC 27410, **James S. Sochacki** (sochacjs@jmu.edu), Department of Mathematics and Statistics, James Madison University, Harrisonburg, VA 22807, and **Stephen K. Lucas** (lucassk@jmu.edu), Department of Mathematics and Statistics, James Madison University, Harrisonburg, VA 22807. *Analyzing Leah Cosine and Leah Sine through Polynomial Projection.*

Mickens defined the functions Leah Cosine (Lcos) and Leah Sine (Lsin), respectively, as the solutions to $y'' + y^{1/3} = 0, y(0) = 1$ and $y'(0) = 0$, and $y'' + y^{1/3} = 0, y(0) = 1$ and $y'(0) = 0$, making them non-linear analogues to cosine and sine. Mickens and some of his students looked for closed-form solutions and gave qualitative descriptions of the functions. In this talk we study Lcos and Lsin through the lens of polynomial projection, identifying the power series for each function and computing the period. The analysis of Lcos comes directly from the theory of polynomial projection and the analysis of Lsin illustrates issues currently pertinent to the study of the topological boundary of sets of power series which solve ODE's with polynomial generators of fixed degree and on domains of fixed dimension. (Received September 11, 2012)

- 1086-34-784 **Andrew A Roberts*** (arob@live.unc.edu). *Multi-scale Analysis in Ocean Circulation Models.*

Stommel's model captures the basic dynamics of thermohaline circulation but does not exhibit self-sustained oscillations in the mode of circulation. The goal is to determine minimal conditions under which a model exhibits such oscillations, which are believed to be integral to Dansgaard-Oeschger events. An attempt is made by appending a deep ocean box, which provides the opportunity to view convective instability as a driving force for oscillations. The model is analyzed using geometric singular perturbation theory, which producing a caricature of the dynamics on multiple time scales. The model does not exhibit self-sustaining oscillations with constant forcing terms and without dynamic sea ice. However, the more complex Saha-de Verdière model, which has four surface and four deep boxes, does exhibit self-sustaining oscillations with dynamic sea ice. (Received September 12, 2012)

- 1086-34-908 **J Diego Ramirez*** (diego.ramirez@lamar.edu), Lamar University, P.O. Box 10047, Beaumont, TX 77710, and **Aghalaya S. Vatsala**, University of Louisiana at Lafayette. *Applications of Contractive Mappings to Fractional Differential Equations with Periodic Boundary Conditions.*

The well known Banach contraction theorem has been one of the main results for proving existence and uniqueness of initial value problems.

Recently the study of weakly contractive mappings has become an important subject in the study of ordinary differential equations with periodic boundary conditions.

In this talk we will mention some fixed point theorems involving weakly contractive conditions and define lower and upper solutions of fractional differential equations. Finally we show an application of these results to Caputo fractional differential equations of order q , $0 < q < 1$, with periodic boundary conditions. We will show that if the problem has a lower solution and it satisfies certain conditions, then it has a unique solution. (Received September 15, 2012)

- 1086-34-1007 **Aghalaya S Vatsala*** (vatsala@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, and **Sownya Muniswamy** (sxm6009@louisiana.edu) and **Donna Sue Stutson** (dstutson@xula.edu). *Numerical Methods for Fractional Differential Equations Via Generalized Monotone Method.* Preliminary report.

Generalized monotone method is an efficient technique to solve fractional differential equations, specially with initial conditions. The method provides the existence of coupled minimal and maximal solutions. The method also provides both theoretical existence results as well as a numerical approach. Further, the approximations are solutions of very simple linear equations without requiring computing the Mittag-Leffler functions. The

challenge is to compute the coupled lower and upper solutions that will be valid to any desired time interval. This is precisely what we do in this work and also present some numerical results. (Received September 17, 2012)

1086-34-1044 **Qingkai Kong*** (kong@math.niu.edu), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115, and **Thomas E. St. George**, Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115. *Matching Method for Nodal Solutions of Multi-Point Boundary Value Problems.*

In this paper, we study the nonlinear boundary value problem consisting of the equation $y'' + w(t)f(y) = 0$ on $[a, b]$ and two multi-point boundary conditions. We establish the existence of various nodal solutions of this problem by matching the solutions of two boundary value problems, each of which involves one separated boundary condition and one multi-point boundary condition, at some point in (a, b) . We also obtain conditions for this problem not to have certain types of nodal solutions. (Received September 18, 2012)

1086-34-1055 **Johnny Henderson** (johnny_henderson@baylor.edu), One Bear Place #97328, Waco, 76798-7328, and **Xueyan (Sherry) Liu*** (xueyan_liu@baylor.edu), One Bear Place #97328, Waco, 76798-7328. *Positive solutions of fractional differential equations with bounded linear functional boundary conditions.*

The authors are concerned about the existence of positive solutions of boundary value problem for a type of fractional differential equations. Boundary conditions involved with bounded linear functionals are studied. (Received September 18, 2012)

1086-34-1193 **Ali Akgul*** (aadt3@mst.edu), 400 west 12th street Rolla building, third floor 306, Rolla, MO 65401. *A new application of the reproducing kernel Hilbert space method to solve MHD Jeffery-Hamel flows Problem in non-parallel walls.*

The present paper emphasizes Jeffery Hamel flow: fluid flow between two rigid plane walls, where the angle between them is 2α . Jeffery-Hamel flow has been studied and its strongly nonlinear ordinary differential equation has been solved through the reproducing kernel Hilbert space method (RKHSM). the validity of the reproducing kernel method is set by comparing our results with the homotopy analysis method (ham), the differential transform method (DTM), the homotopy perturbation method (HPM), the spectral-homotopy analysis method (SHAM) and numerical results for different values of h, α and re . the results show that the proposed reproducing kernel method can achieve good results in predicting the solutions of such problems. Comparison between obtained results showed that RKHSM is more acceptable and accurate than other methods. (Received September 23, 2012)

1086-34-1350 **Tadesse G Zerihun***, Department of Mathematics and Statistics, 4202 east Fowler Avenue, CMC 342, Tampa, FL 33620-5700, and **Gangaram S Ladde** (gladde@usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, CMC 342, Tampa, FL 33620-5700. *Energy Function Method and Stochastic Variational Comparison Theorems.* Preliminary report.

Employing energy function method and the fundamental properties of Ito-Doob type stochastic auxiliary systems of differential equations, we establish the relationship between the solution processes of stochastic auxiliary, comparison, perturbed and unperturbed systems of differential equations. The stochastic differential inequalities and comparison theorems are used to obtain the estimates on the solution of the perturbed system. In addition, several estimates are obtained with regard to the deviation of solution process of perturbed with respect to the solution process of unperturbed system. Examples are given to illustrate the usefulness of the results. (Received September 21, 2012)

1086-34-1639 **Faina Berezovskaya*** (fberezovskaya@howard.edu), Mathematics Department, Howard University, 6 str., Washington, DC 20059. *Asymptotic Behavior of Orbits of Kolmogorov Type Planar Vector Fields with a Fixed Newton Polygon.*

Using the Newton polygon technique we show that the orbits of a Kolmogorov type general planar vector field of quasi-polynomial form have power asymptotics, while tending to the equilibria on the axes and on the equators of the Poincaré sphere. Conditions of the non-degeneracy of a vector field, values of the powers and the coefficients of asymptotics are expressed with help of characteristics of the Newton polygon, which is the convex hull of the quasi-polynomial powers. (Received September 23, 2012)

- 1086-34-1674 **Zachary Denton*** (zdenton@ncat.edu) and **Aghalaya Vatsala**. *Iterative Technique for Nonlinear Riemann-Liouville Fractional Differential Equations*. Preliminary report.
Existence and comparison results of the linear and nonlinear Riemann-Liouville fractional differential equations and nonlinear systems of order q , $0 < q < 1$, are recalled and modified where necessary. Generalized iterative technique is developed for decomposed nonlinear fractional differential equations of order q , using coupled upper and lower solutions. Uniform convergence is proved via weighted sequences. (Received September 24, 2012)
- 1086-34-1709 **R. Thelwell***, thelwerj@jmu.edu. *Power Series, Automatic Differentiation and Differential Equations*.
Power Series have historically been a powerful tool in the study of Differential Equations. We'll review a little of the history, and make new connections to method of Automatic Differentiation. Examples will include ODE, Analytic Continuation, Root finding and Special Functions. (Received September 24, 2012)
- 1086-34-1781 **Milica Miko Vesovic*** (mvesov2@uic.edu), 851 S. Morgan St., SEO 322, Chicago, IL 60607, and **Hassan Fathallah-Shaykh** and **Jerry Bona**, IL. *Drosophila Jet Lag*.
Shifts in the circadian rhythm of mammals and insects have been observed to occur during spatial dislocations involving significant time zone changes. Following such dislocations, the system of proteins that comprises the circadian clock move the body toward a new stable waking/sleeping equilibrium, consistent with the altered environment.
Using a recently developed model developed by Fathallah-Shaykh, Bona and Kadner that we believe captures the full *Drosophila*'s (fruit fly's) circadian clock, we report predictions of how the *Drosophila* adjusts its waking/sleeping rhythm to both instantaneous and more gradual time-zone shifts. (Received September 24, 2012)
- 1086-34-1820 **Joseph Bulatowicz*** (jbulatowicz@live.com), 33 E 19th St Apt 4, Bayonne, NJ 07002, **Eric Ledesma** (eric.ledesma@rocketmail.com), 117 Audubon Avenue, Jersey City, NJ 07305, **Zhixiong Chen** (zchen@njcu.edu), 2039 Kennedy Boulevard, Jersey City, NJ 07305, and **Yi Ding** (yding@njcu.edu), 2039 Kennedy Boulevard, Jersey City, NJ 07305. *Modeling the Effect of Alcohol on Glucose Regulation*. Preliminary report.
Many organisms utilize glucose as their main source of energy. Glucose, a simple carbohydrate, is metabolized from the foods organisms consume or is synthesized within the organism. In healthy individuals, the body is able to regulate the amount of glucose present in the bloodstream. However, people with a condition known as diabetes mellitus are unable to successfully carry out proper glucose metabolism. In previous studies, ethanol, or drinking alcohol, caused hypoglycemia in humans, which is further exacerbated in diabetics. A system of ordinary differential equations was created to include ethanol as a parameter of the blood glucose regulation system. This mathematical model may be utilized in future studies including blood glucose management and alcohol consumption. (Received September 24, 2012)
- 1086-34-1859 **jagdish chandra*** (jchandra@gwu.edu), 6504 great drum circle, columbia, MD , and **G.S. Ladde**. *Energy Methods for Dynamic Stochastic Models of Social Networks*. Preliminary report.
Dynamic social networks as group decision-makers are modeled as coupled systems (both deterministic and stochastic) of differential equations. We develop energy methods to explore properties such as coherence, stability, and robustness of interactions among such multi-agent systems. (Received September 24, 2012)
- 1086-34-1877 **Brenda M. Jaurrieta**, **Wilson E. Alvarez**, **Itelhomme Fene**, **Kimberly Gutstein*** (khg7@humboldt.edu), **Diego Chowell**, **Anuj Mubayi** and **Luis Melara**. *Prisoner Reform Programs, and their Impact on Recidivism*.
The California prison system has a high percentage of people who return to prison within a three year period after release. A mathematical model is formulated to study the effectiveness of Reentry Court programs for first time offending parolees designed to reduce the prison return rates when implemented alone or in conjugation with an in prison educational program. Parolees who participated in both in/out of prison programs are referred to as an ideal class in the model. Stability analysis and numerical simulations were carried out to study the impact of the programs. The results show that the reentry program reduces the recidivism rate more than the Basic Educational program within the prison system, but only when social influence of criminals is low outside of prison. However, for populations with high rates of social influences, incarceration rates should be large in order to get the same impact of the reentry program. (Received September 24, 2012)

1086-34-2331 **Dan M Maroncelli*** (dmmaronc@ncsu.edu), 2108 SAS Hall, Box 8205, Raleigh, NC 27695, and **Jesus Rodriguez**. *On the solvability on nonlinear impulsive boundary value problems at resonance.*

The authors consider nonlinear impulsive boundary value problems of the form

$$x'(t) = A(t)x(t) + f(t, x(t)), \quad t \in [0, 1] \setminus \{t_1, t_2, \dots, t_k\} \quad (1)$$

$$x(t_i^+) - x(t_i^-) = J_i(x(t_i^-)), \quad i = 1, \dots, k \quad (2)$$

subject to

$$Bx(0) + Dx(1) = 0. \quad (3)$$

We focus on the case of resonance, in particular, the case in which dimension of the solution space to the associated linear homogeneous problems is greater than one. (Received September 25, 2012)

1086-34-2360 **Bruno D. Welfert*** (welfert@asu.edu), School of Math. & Stat. Sciences, Arizona State University, Tempe, AZ 85287, and **Juan M. Lopez** (jmllopez@asu.edu), School of Math. & Stat. Sciences, Arizona State University, Tempe, AZ 85283. *Slow passage through resonance: the big picture.* Preliminary report.

We consider the response of the model oscillator problem

$$\ddot{x} + \gamma \dot{x} + x = \sin\left(\frac{1}{\epsilon} f(\epsilon t)\right),$$

where $\epsilon \ll 1$ is a small parameter and f is a general function. For example, the choice $f(\tau) = (\omega_0 + \tau)\tau$ corresponds to a slowly drifting frequency, for which it has recently been shown that x exhibits a dynamic behavior which differs from the constant frequency case, in particular an early resonance at a frequency depending on ω_0 .

We show that the right-hand side in the above model can be very well approximated, in the limit $\epsilon \rightarrow 0$, by the superposition of on-off switches (modeled by Heaviside terms) at critical times characterized by $|f'(\epsilon t_c)| = 1$, and whose amplitude depends on the curvature $|f''(\epsilon t_c)|$.

Various choices of forcing functions f are used to illustrate the result, and extensions to stochastic forcing functions f are discussed. (Received September 25, 2012)

1086-34-2499 **Susmita Sadhu*** (susmita.sadhu@gcsu.edu) and **Joseph E Paullet**. *Asymptotic behavior of solutions of a BVP arising from fluid mechanics.*

The boundary value problem (BVP) governing a boundary layer flow past a suddenly heated vertical surface in a saturated porous medium is given by

$$f''' = \frac{2k+1}{3} f'^2 - \frac{k+2}{3} f f''$$

$$f(0) = 0, \quad f''(0) = -1, \quad f'(\infty) = 0,$$

where $k > -1$ is the temperature gradient exponent. Previous results have established the existence of a continuum of solutions for $-1 < k < -1/2$. In this talk, we will consider the asymptotics of these solutions. We will prove that for each $-1 < k < -1/2$, there exists a solution f_0 of the BVP that satisfies

$$f'_0(\eta) \sim c_0 f_0(\eta)^{-\frac{3(k+1)}{k+2}} \exp\left(-\int_{\eta_0}^{\eta} f_0(s) ds\right)$$

as $\eta \rightarrow \infty$ for some $\eta_0 > 0$ sufficiently large, and a constant $c_0 > 0$ that depends only on k and η_0 . We conjecture that the BVP has exactly one solution that obeys the above asymptotics, i.e. its derivative decays to zero exponentially, while the derivatives of the other solutions decay to zero algebraically. If time permits we will also discuss uniqueness of solutions in the range $0 \leq k \leq 1$. (Received September 25, 2012)

1086-34-2796 **Clayton J Schuman*** (cjs5510@psu.edu) and **Antonio Mastroberardino** (axm62@psu.edu). *Multi-Dimensional Predator-Prey Models.*

In this study, we consider predator-prey models with one predator and multiple prey. We begin with an analysis of a one-predator, two-prey system in which there is no competition between the prey. We determine conditions for the existence of a nonzero fixed point and discuss stability. We then generalize our results to the case of a one-predator, n-prey system. Using this generalized system, it is possible to display certain characteristics of the system with regards to introduced prey species and behaviors of arbitrarily large ecosystems. (Received September 25, 2012)

1086-34-2956 **My Linh Nguyen*** (mln018200@utdallas.edu), 800 W Campbell Rd, Richardson, TX 75080. *Multiple solutions to second order symmetric boundary value problems: equivariant degree approach.*

The solubility of second order boundary value problems (BVPs) is attracting a big deal of attention for a long time. As a matter of fact, symmetric BVPs (i. e. the ones having the right-hand side commuting with some compact Lie group representation) almost always admit multiple solutions since the solutions are coming in orbits. We develop a new approach to the problem in question based on the usage of the so-called equivariant degree introduced by J. Ize et al. – a topological tool allowing “counting” orbits of solutions to symmetric equations in the same way as the usual Brouwer degree does it, but according to their symmetric properties. This method is an alternative and/or complement to the equivariant singularity theory developed by M. Golubitsky et al., as well as to a variety of methods rooted in Morse Theory, Lusternik- Schnirelman Theory and Morse-Floer complex techniques used for a treatment of variational problems with symmetries. We establish multiplicity results for the second order BVPs exhibiting different symmetric topological behavior near the origin and infinity. General results are illustrated by concrete examples exhibiting dihedral symmetries. This is a joint work with Z. Balanov and W. Krawcewicz. (Received September 26, 2012)

35 ► *Partial differential equations*

1086-35-6 **Cédric Villani***, Université de Lyon, Department of Mathematics, 11 rue Pierre et Marie Curie, F-75231 Paris, Cedex 05, France. *On disorder, mixing and equilibration.*

Since the Maxwell-Boltzmann statistical conceptual revolution of 1860-1870, two main paradigms have emerged as a guide for equilibration processes: Boltzmann’s entropy growth principle on the one hand, Landau’s damping by mixing on the other hand. These are fundamentally different mechanisms, coming in different settings and with different phenomenologies, which can sometimes reinforce each other. I will review progress in this area in the past 15 years, and the many problems which have emerged at the same time.

(Received March 26, 2012)

1086-35-38 **Steve M. Anglin, Ph.D. (h.c.), Sc.M.*** (stevemanglin@yahoo.com), PO BOX 1291, Mountain View, CA 94042. *Partial Differential Equations Practicum.*

In this Partial Differential Equations (PDEs) practicum, we show practical and quick ways for solving linear and nonlinear PDEs. More specifically, we find analytic solutions to linear PDEs; first order linear/nonlinear PDEs; and higher order nonlinear PDEs. For example, we can find solutions to equations like Vlasov-Maxwell, Poisson’s, Ricci, KdV, and many more as well as variations of these encountered in practice and research. (Received June 10, 2012)

1086-35-40 **Michael Sever*** (sever@math.huji.ac.il), 76 Shenkin St., apt. 4, 65223 Tel-Aviv, Israel. *Continuation of weak solutions of systems of conservation laws.*

Sufficient conditions are established for the continuation of weak solutions of nonlinear systems of conservation laws as the initial/boundary data is varied. The symmetric form of the given system is essential in this discussion, but neither a single space dimension nor small data is assumed. The results illuminate specific obstacles to obtaining existence theorems by this means. Perhaps unsurprisingly, in the case of multiple space dimensions, the principal difficulty is the need to solve a class of generalized Riemann problems. In the case of a single space dimension, the familiar obstacles to continuation to large data are possible blowup in L^∞ and the appearance of classically unsolvable Riemann problems. It is seen here that in the absence of such phenomena, continuation to large data is broadly possible. (Received June 11, 2012)

1086-35-62 **Naoto Kumano-go*** (ft24343@ns.kogakuin.ac.jp), 1-24-2, Nishishinjuku, Shinjuku-ku, Tokyo, 163-8677. *Phase space Feynman path integrals with smooth functional derivatives by time slicing approximation.*

We give two general classes of functionals for which the phase space Feynman path integrals have a mathematically rigorous meaning. More precisely, for any functional belonging to each class, the time slicing approximation of the phase space path integral converges uniformly on compact subsets with respect to the starting point of momentum paths and the endpoint of position paths. Each class is closed under addition, multiplication, translation, real linear transformation and functional differentiation. Therefore, we can produce many functionals which are phase space path integrable. Furthermore, though we need to pay attention for use, the interchange of the order with the integrals with respect to time, the interchange of the order with some limits, the semiclassical approximation of Hamiltonian type, the natural property under translation, the integration by parts with respect

to functional differentiation, and the natural property under orthogonal transformation are valid in the phase space path integrals. [1] N. Kumano-go, Bull. Sci. math. 135 (2011), 936–987. (Received June 27, 2012)

1086-35-64 **Xuehua Chen*** (dandan.jhu@gmail.com), 404 Krieger Hall, 3400 N. Charles St., Baltimore, MD 21218. *An improvement on eigenfunction restriction estimates for compact boundaryless Riemannian manifolds with nonpositive sectional curvature*. Preliminary report.

Let (M, g) be an n -dimensional compact boundaryless Riemannian manifold with nonpositive sectional curvature, then our conclusion is that we can give improved estimates for the L^p norms of the restrictions of eigenfunctions to smooth submanifolds of dimension k , for $p > \frac{2n}{n-1}$ when $k = n-1$ and $p > 2$ when $k \leq n-2$, compared to the general results of Burq, Gérard and Tzvetkov. We give the improved estimates for $n = 2$, the L^p norms of the restrictions of eigenfunctions to geodesics. Our proof uses the fact that, the exponential map from any point in $x \in M$ is a universal covering map from $\mathbb{R}^2 \simeq T_x M$ to M , which allows us to lift the calculations up to the universal cover $(\mathbb{R}^2, \tilde{g})$, where \tilde{g} is the pullback of g via the exponential map. Then we prove the main estimates by using the Hadamard parametrix for the wave equation on $(\mathbb{R}^2, \tilde{g})$, the stationary phase estimates, and the fact that the principal coefficient of the Hadamard parametrix is bounded, by observations of Sogge and Zelditch. The improved estimates also work for $n \geq 3$, with $p > \frac{4k}{n-1}$. We can then get the full result by interpolation. (Received June 29, 2012)

1086-35-100 **Joel Kilty*** (joel.kilty@centre.edu), 600 W. Walnut Street, Centre College, Danville, KY 40422, and **Jun Geng**. *The L^p Regularity Problem for the Stokes System on Lipschitz Domains*.

The goal of this talk is to present two results concerning the stationary Stokes system on bounded Lipschitz domains. The first result establishes a necessary and sufficient condition for the solvability of the $L^p(\partial\Omega)$ regularity problem when $p > 2$ in terms of a weak reverse Hölder inequality for $L^2(\partial\Omega)$ solutions which vanish on part of the boundary. The second result establishes the $W^{1,p}(\Omega)$ estimate for solutions of a Poisson-type Dirichlet problem when $|\frac{1}{p} - \frac{1}{2}| < \frac{1}{2d} + \varepsilon$ on a bounded Lipschitz domain $\Omega \subset \mathbb{R}^d$. (Received July 17, 2012)

1086-35-110 **Jongkeun Choi*** (cjg@yonsei.ac.kr), Department of Mathematics, Yonsei University, Seoul 120-749, South Korea, and **Seick Kim** (kimseick@yonsei.ac.kr), Department of Mathematics, Yonsei University, Seoul 120-749, South Korea. *Green's function for second order parabolic systems with Neumann boundary condition*.

We study the Neumann Green's function for second order parabolic systems in divergence form with time-dependent measurable coefficients in a cylindrical domain $\mathcal{Q} = \Omega \times (-\infty, \infty)$, where $\Omega \subset \mathbb{R}^n$ is an open connected set such that a multiplicative Sobolev embedding inequality holds there. Such a domain includes, for example, a bounded Sobolev extension domain, a special Lipschitz domain, and an unbounded domain with compact Lipschitz boundary. We construct the Neumann Green's function in \mathcal{Q} under the assumption that weak solutions of the systems satisfy an interior Hölder continuity estimate. We also establish global Gaussian bounds for Neumann Green's function under an additional assumption that weak solutions with zero Neumann data satisfy a local boundedness estimate. (Received July 20, 2012)

1086-35-163 **Adrian I Nachman*** (nachman@math.toronto.edu), Dept. of Mathematics and, Dept. of Electrical and Computer Engineering, University of Toronto, Toronto, Ontario M5S 2E4, Canada. *Inverse Problems with Minimal Interior Measurements*.

Imaging electric conductivity of tissue is both desirable and challenging. The classical Electric Impedance Tomography Problem seeks to determine the conductivity from measurements of voltages and currents at the boundary; it has spurred deep and far-reaching mathematical developments. The ill-posedness of the problem is now well understood, and places severe limitations on the resolution that can be achieved.

Recent research on Hybrid Inverse Problems seeks to overcome such limitations in classical inverse boundary value problems by coupling two physical modalities to obtain new interior data. We will discuss one such approach: imaging conductivity from interior current density data obtainable using MRI in a novel way. We only require knowledge of the magnitude of one current for a given voltage on the boundary. We show that the corresponding equipotential surfaces are area minimizing in a conformal metric determined by the given data. Using geometric measure theory and convex analysis techniques, we prove identifiability and give convergent reconstruction algorithms. We'll present theoretical, numerical and experimental results from joint work with Robert Jerrard, Michael Joy, Weijing Ma, Tim DeMonte, Amir Moradifam, Alexandru Tamaskan and Alexandre Timonov. (Received September 25, 2012)

1086-35-186 **Katelyn J Grayshan*** (kgraysha@nd.edu), 255 Hurley Hall, Notre Dame, IN 46556.
Continuity Properties of Camassa–Holm Type Equations.

We examine the well-posedness in Sobolev spaces of a class of weakly dispersive nonlinear evolution equations including the Camassa–Holm, Degasperis–Procesi, and Novikov equations. In particular, we consider the continuity properties of the data-to-solution map corresponding to each shallow water equation.

In Sobolev spaces H^s with $s > 3/2$, we show that each data-to-solution map is continuous from H^s to $C([0, T]; H^s)$. We refine this by proving that each map is not uniformly continuous on bounded subsets of H^s ; however, with a weaker choice of topology, the map is Hölder continuous. The proof of non-uniform continuity is based on approximate solutions and delicate commutator and multiplier estimates. For $s < 3/2$, we prove that each data-to-solution map is not (globally) uniformly continuous by constructing a sequence of peakon solutions whose distance initially goes to zero but later becomes large. (Received August 05, 2012)

1086-35-187 **Katelyn J Grayshan*** (kgraysha@nd.edu), 255 Hurley Hall, Notre Dame, IN 46556.
Analysis of the b-family equation.

We study a family of shallow water wave equations called the b-family equation. Known for having multipeakon solutions, this family includes the Camassa–Holm equation and the Degasperis–Procesi equation as its most notable and only integrable members. We show that the periodic and non-periodic Cauchy problem for the b-family equation is well-posed in Sobolev spaces H^s with exponent $s > 3/2$. Moreover, we find that the corresponding data-to-solution map is continuous from H^s to $C([0, T]; H^s)$ but not uniformly continuous on bounded subsets. We prove that this map is not uniformly continuous using approximate solutions together with delicate commutator and multiplier estimates. The novelty of the proof lies in the fact that it makes no use of conserved quantities. (Received August 05, 2012)

1086-35-196 **Aditi Ghosh*** (amathematics@gmail.com), Bryan, TX 77801, and **Prabir Daripa** (daripa@math.tamu.edu), College Station, TX 77840. *A Fast Algorithm to solve the Biharmonic equation with application to slow viscous flow.*

We present here a very accurate fast algorithm to solve the inhomogeneous Biharmonic equation with different boundary conditions in the interior of a unitdisk of the complex plane. The fast algorithm is based on the representation of the solution in terms of Green functions, fast Fourier transform and some recursive relation derived in the Fourier space. The fast solver is derived through exact analysis and properties of convolution of integrals using Greens function and hence is very accurate. The numerical evaluation of the double integrals has been optimized giving an asymptotic operation count $O(\ln N)$ per point on the average and requires no additional memory storage except the initial data. It has been implemented, validated and applied to solve several interesting applied problems from fluid mechanics and electrostatics. (Received August 14, 2012)

1086-35-319 **Indranil SenGupta*** (indranil.sengupta@ndsu.edu), Department of Mathematics, North Dakota State University, Fargo, ND 58108, and **Maria C Mariani** and **Ionut Florescu**.
PDE model, stochastic volatility and transaction costs.

Option pricing with transaction costs and stochastic volatility leads to a nonlinear Black-Scholes type equation where the nonlinear term reflects the presence of transaction costs. We derive the model with transaction costs and we extend it to the case where the volatility is stochastic. When using a stochastic volatility model the market is incomplete and the option price is not unique. However, under a particular market completion assumption we derive the nonlinear PDE whose solution may be used to find the price of options. Under suitable conditions, we prove the existence of strong solutions of the problem. We give many practical examples when our model can be used. (Received August 20, 2012)

1086-35-321 **Lakshmi S Kalappattil*** (lk154@msstate.edu), 319 N Jackson St, Apt 6 B, Starkville, MS 39759. *Semipositone Problems on Exterior Domains.*

We study nonnegative radial solutions to the problem

$$\begin{cases} -\Delta u = \lambda K(|x|)f(u), & x \in \Omega \\ u = 0 & \text{if } |x| = r_0 \\ u \rightarrow 0 & \text{as } |x| \rightarrow \infty, \end{cases}$$

where λ is a positive parameter, $\Delta u = \operatorname{div}(\nabla u)$ is the Laplacian of u , $\Omega = \{x \in \mathbb{R}^n; n > 2, |x| > r_0\}$ and K belongs to a class of functions such that $\lim_{r \rightarrow \infty} K(r) = 0$. For classes of nonlinearities f that are negative at the origin we discuss existence and uniqueness results. (Received August 20, 2012)

- 1086-35-331 **Ranis N Ibragimov*** (ranis.ibragimov@utb.edu), Brownsville, TX 78520. *Mathematical Modeling of Hurricanes and Atmospheric & Oceanic Whirlpools by Means of Linear and Nonlinear Internal Kelvin Waves Confined in Cylindrical Basins.*

The effects of the Earth's rotation on three dimensional stratified fluids confined in a rigid cylindrical basin were examined analytically and numerically. The time series of the energy density were visualized as spinning patterns that appear to be rotating in an anticlockwise sense when looking from above the North Pole. Such spinning patterns were compared with the flow around a low-pressure area that is usually being linked with a modeling of hurricanes. The exact solutions to the nonlinear model are found by means of approximate transformation groups of equations with a small parameter. Introduction of the small parameter has been motivated by justifying the analogy of the Kelvin hypothesis on the velocity component normal to a wall vanishing throughout the domain. One of the invariant solutions was visualized as funnels having something in common with the geometric structure of oceanic whirlpools. The deep-water whirlpools - part of the ocean's complex circulatory system, help drive the ocean currents that moderate Earth's climate. These whirlpools play a key role in global climate as well, transporting ocean heat from the equator northward and eventually feeding into the Gulf Stream system. The natural phenomenon, which creates the whirlpools, is unknown to modern science. (Received August 21, 2012)

- 1086-35-410 **Dimitri Puhst*** (puhst@math.tu-berlin.de), Technische Universität Berlin, Institut für Mathematik, Straße des 17. Juni 136, 10623 Berlin, Germany. *Results on the well-posedness of nonlinear peridynamics.*

Nonlocal phenomena in elastic materials taking into account effects of long-range interaction have been studied for a long time. Nevertheless, nonlocal theories have gained more and more interest recently. In particular peridynamics, a nonlocal continuum theory based on an in general nonlinear integro-differential equation without spatial derivatives, is a current matter of research both analytical and numerical. In this talk we will show well-posedness of the nonlinear multi-dimensional peridynamic initial value problem under the assumption of Lipschitz-type continuity of the pairwise force function in its second argument.

This is a joint work with Prof. Dr. Etienne Emmrich. (Received August 30, 2012)

- 1086-35-423 **Jiuyi Zhu*** (jiuyi.zhu@wayne.edu), 1150 Faculty/Administration Building, 656 W. Kirby, Detroit, MI 48202, and **Guozhen Lu**. *Maximum Principle and Symmetry results for Viscosity Solution of Fully Nonlinear Equations.*

The paper is concerned about maximum principle and radial symmetry for viscosity solution of fully nonlinear equations. We obtain the radial symmetry, monotonicity for nonnegative viscosity solution of

$$F(D^2u) + u^p = 0 \quad \text{in } \mathbb{R}^n \quad (1)$$

under asymptotic rate $u = o(|x|^{-\frac{2}{p-1}})$ at infinity, where $p > 1$. New maximum principle for fully nonlinear elliptic equation are established. Our results apply to Pucci's extremal operators, Bellman or Isaccs equations. Radial symmetry, monotonicity and the corresponding maximum principle for fully nonlinear elliptic equation in a punctured ball are shown. We also investigate the radial symmetry for viscosity solution of fully parabolic equations. (Received August 31, 2012)

- 1086-35-497 **Otis Chodosh, Vishesh Jain** (visheshj@stanford.edu), **Michael Lindsey, Lyuboslav Panchev*** (lpanchev@stanford.edu) and **Yanir A. Rubinstein**. *On the discontinuity of optimal transportation maps.*

Consider two bounded domains Ω and Λ in \mathbb{R}^2 , and two sufficiently regular probability measures μ and ν supported on them. By Brenier's theorem, there exists a unique optimal transportation map T satisfying $T_{\#}\mu = \nu$ and minimizing the quadratic cost $\int_{\mathbb{R}^n} |T(x) - x|^2 d\mu(x)$. Furthermore, by Caffarelli's regularity theory for the real Monge-Ampère equations (1990's) if Λ is convex, T is continuous. We study the converse problem, namely: how discontinuous is the map T when Λ fails to be convex? We prove a number of results relating the geometry of Λ to the (dis)continuity of T . The main idea is to use tools of convex analysis and the extrinsic geometry of $\partial\Lambda$ to distinguish between Brenier and Alexandrov weak solutions of the Monge-Ampère equation. (Received September 05, 2012)

- 1086-35-514 **Fabrice Baudoin** (fbaudoin@math.purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47907-2067, and **Jing Wang*** (wang321@purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47907-2067. *Curvature-Dimension Inequalities and Ricci Lower Bounds for Contact Manifolds*. Preliminary report.

Let M be a contact Riemannian manifold. The sub-Laplacian L on M is a symmetric diffusion operator which is subelliptic but nowhere elliptic. We study Bochner's type formulas for L and, as a consequence, prove that

under suitable geometric bounds spectral gap estimates can be obtained as well as gradient estimates for the heat semi- group. (Received September 05, 2012)

- 1086-35-530 **Weishi Liu** (wliu@math.ku.edu), 405 Snow Hall 1460 Jayhawk Blvd, Lawrence, KS 66045, **Xuemin Tu** (xtu@math.ku.edu), 405 Snow Hall 1460 Jayhawk Blvd, Lawrence, KS 66045, and **Mingji Zhang*** (mingjizhang@math.ku.edu), 405 Snow Hall 1460 Jayhawk Blvd, Lawrence, KS 66045. *Pitch-fork bifurcation of a steady-state Poisson-Nernst-Planck systems for ion channels with permanent charge: Multiple I-V relations.*

We consider a one-dimensional Poisson-Nernst-Planck(PNP) model for ionic flow through ion channels for two ion species with permanent charges. The PNP model problem can be viewed as a boundary value problem of a singularly perturbed system and the existence of solutions is reduced to that of an algebraic system. Multiple solutions are shown to exist, under some conditions, through bifurcation analysis and numerical computations are consistent with our analysis. Existence of multiple solutions in such or similar models might be relevant to complex behaviors of ion channels. (Received September 05, 2012)

- 1086-35-554 **Lidia Bloshanskaya***, Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409-1042, Lubbock, TX 79409, and **Akif Ibragimov**, **Eugenio Aulisa** and **Luan Hoang**. *Time Asymptotics Of Non-Darcy Flows Controlled By Total Flux On The Boundary.*

We study of long term asymptotic of diffusive capacity, the integral characteristic of the domain with respect to non-linear Forchheimer flow in porous media. Conditions on the boundary are given in terms of the total flux and constraints on the trace of the pressure on the boundary. It is proved that if total flux stabilizes then the difference between pressure average inside domain and on the boundary stabilizes as well. The refined comparison of fully transient and pseudo steady state pressure (the time derivative of pressure is constant) is performed. These results can be effectively used in reservoir engineering and can also be applied in other problems modeled by non-linear diffusive equations. (Received September 06, 2012)

- 1086-35-586 **Lihua Zuo***, lzuo@math.tamu.edu, and **Xu and Rundell**. *inverse boundary and source problem for fractional diffusion equations.*

Inverse boundary and source problems for time-fractional diffusion equations are considered in this presentation, in which either the nonlinear flux function on the boundary or the nonlinear source function is unknown and to be determined. In contrast to the standard diffusion kernel, we have new fractional kernel so there will be challenges analytically and numerically. Based upon the free space fundamental solution, we derive a representation for the solution for the forward problem. Then a mapping will be constructed by the forward solution and to be shown as a contraction map so we get the uniqueness and reconstructibility under some assumptions and applying the fixed point theorem. Numerical examples will be presented to illustrate the validity and effectiveness of the proposed method. (Received September 07, 2012)

- 1086-35-630 **Kazuo Yamazaki*** (kyamazaki@math.okstate.edu), Oklahoma State University, Dept. Mathematics, 401 Mathematical Sciences Building, Stillwater, OK 74078. *Regularity criteria of active scalars in terms of partial derivatives.*

Active scalars play important roles in understanding fluid mechanics. Recently while their global regularity issue has received much attention from many mathematicians, it remains to be a challenging topic in the supercritical case.

We obtain new regularity criteria and smallness condition for the global regularity of the solution to the N-dimensional active scalars convected by incompressible fluid. In particular, it is shown that in order to obtain global regularity results, one only needs to bound its partial derivatives, dropping the condition on one direction. The results may be applied to the surface quasi-geostrophic equation in case $N = 2$ and furthermore porous media equation governed by Darcy's law in case $N = 2$ or 3. Further extension will also be shown in the case of porous media equation. (Received September 09, 2012)

- 1086-35-673 **Robert Carlson*** (rcarlson@uccs.edu), Department of Mathematics, 1420 Austin Bluffs Parkway, University of Colorado, Colorado Springs, CO 80933, **Jonathan Sarhad** (jonathan.sarhad@gmail.com), Department of Biology, University of California Riverside, Riverside, CA, and **Kurt Anderson** (kurt.anderson@ucr.edu), Department of Biology, University of California Riverside, Riverside, CA. *Population persistence in river networks.*

Quantum graph methods are used to develop and study river system population models that explicitly incorporate river network geometry. Population persistence is adversely affected by downstream drift and lethal boundaries.

By recasting the persistence question as an eigenvalue problem, the dependence on dispersal parameters, network geometry, boundary conditions, and volume measures can be treated. (Received September 13, 2012)

1086-35-728 **Jose Manuel Vega-Guzman*** (jmvega@asu.edu), PO 1782, Tempe, AZ 85280. *Solution Method for Certain Evolution Equations*. Preliminary report.

A method to construct solution of the Cauchy initial value problem for certain linear and nonlinear evolution equations is presented. Emphasis is placed mainly on the analytical treatment of nonautonomous differential equations, which are challenging to solve despite the existent numerical and symbolic computational software programs available at the moment. In the majority of such methods, ideas from Transformation theory are adopted allowing one to solve the initial value problem under consideration. The formulas obtained for the corresponding Kernels involve the solution of a Riccati(or Ermakov) differential equation associated to the problem. Examples from Fluid Dynamics, Finance and Physics will be presented in order to corroborate the method. (Received September 11, 2012)

1086-35-735 **Dipendra Regmi*** (dregmi@math.okstate.edu), 401 MSCS, Oklahoma State University, Stillwater, OK 74078. *Global Regularity Results for 2D Magnetohydrodynamic Equations*. Preliminary report.

We study the global regularity of classical solutions to the 2D incompressible magnetohydrodynamic (MHD) equations with horizontal dissipation and horizontal magnetic diffusion. We establish a global bound for the horizontal component in any Lebesgue space L^{2r} with $1 \leq r < \infty$ and the bound grows no faster than the order of $\sqrt{r} \log r$ as r increases. In addition, we establish a conditional global regularity in terms of the $L_t^2 L_x^\infty$ -norm of the horizontal component and the global regularity of a slightly regularized version of the aforementioned MHD equations. This is a joint work with C. Cao and J. Wu. (Received September 11, 2012)

1086-35-776 **Jahmario Williams***, 110 Lincoln Green Apt 318, Starkville, MS 39759, and **Hai Dang**, 410 Allen Hall 175 President's Circle, Mississippi. *Positive radial solutions for a class of singular p -Laplacian system in a ball*.

We prove the existence and nonexistence of positive radial solutions for the system

$$\begin{cases} -\Delta_p u_1 = h_1(u_2) + \mu_1 f_1(u_2) & \text{in } B, \\ -\Delta_p u_2 = h_2(u_1) + \mu_2 f_2(u_1) & \text{in } B, \\ u_1 = u_2 = 0 \text{ on } \partial B. \end{cases}$$

where $\Delta_p z := \operatorname{div}(|\nabla z|^{p-2} \nabla z)$, $p > 1$, B is the open unit ball in \mathbb{R}^n , $h_i, f_i : (0, \infty) \rightarrow \mathbb{R}$ with f_i asymptotically p -linear at ∞ , and μ_i are positive constants, $i = 1, 2$. (Received September 12, 2012)

1086-35-868 **Jonathan G. Bell*** (jbell@umbc.edu), Department of Mathematics & Statistics, UMBC, Baltimore, MD 21250. *Determining a Distributed Parameter for a Neuronal Cable Model on a Metric Tree Graph*.

The goal in this talk is to discuss the inverse problem of recovering a single spatially distributed conductance parameter in a cable theory model (one-dimensional diffusion equation) defined on a finite tree graph. We employ a boundary control method that gives a unique reconstruction and an algorithmic approach. The motivation for this work is that dendrites of nerve cells are tree-like graphs, which have non-uniformly distributed physical parameters, one being channel conductance. It is also one of the first studies of the application of boundary control methods to inverse problems of parabolic problems on graphs, and one of the first uses of the method in this application area. This is collaborative work with Sergei Avdonin, U. Tennessee at Chattanooga. (Received September 24, 2012)

1086-35-918 **Silvia Jimenez*** (silviajimenez@wpi.edu), 100 Institute Road, Worcester, MA 01609, and **Bogdan Vernescu** and **William Sanguinet**. *Nonlinear Neutral Inclusions: Assemblages of Spheres*. Preliminary report.

If a neutral inclusion is inserted in a matrix containing a uniform applied electric field, it does not disturb the field outside the inclusion. The well known Hashin coated sphere is an example of a neutral coated inclusion. In this talk, we consider the problem of constructing neutral inclusions from nonlinear materials. In particular, we discuss assemblages of coated spheres and the two-dimensional analogous problem of assemblages of coated disks. (Received September 16, 2012)

- 1086-35-958 **Andrew Getz*** (agetz@njcu.edu), 32 Carlton Street South, Edison, NJ 08837, **Bernard R Lipat** (blipat@njcu.edu), 156 Carlton Ave., Apt. 2, Jersey City, NJ 07306, **Zhixiong Chen** (zchen@njcu.edu), 44 Laurel Avenue, Livingston, NJ 08837, and **Yi Ding** (yding@njcu.edu), 45 River Drive South #202, Jersey City, NJ 07310. *Urban Lead and Its Health Consequences on Children: A Mathematical Model*. Preliminary report.

We model the transportation of atmospheric and soil-based lead at the macro- and meso-scales to study its health effects on children in Jersey City, New Jersey. The Crank-Nicolson numerical approximation of the diffusion-advection partial differential equation in three spatial and one temporal dimension is used to calculate the concentration of atmospheric lead that had settled onto the surface of the soil, using as an initial condition a polynomial interpolation which considers lead that had accumulated from automobile exhaust and as a boundary condition the mean lead emissions from a nearby smelting plant. Considering the bioaccessibility and bioavailability of lead, a proportionality based on cumulative exposure over time, as measured by blood concentration, is used to determine the relative health risks. (Received September 17, 2012)

- 1086-35-961 **Suzanne Lenhart*** (lenhart@math.utk.edu), U of Tennessee, Math Dept, Knoxville, TN 37996, and **Sergei Avdonin** and **Jason Bintz**. *An application of Parabolic PDEs on graphs*. Preliminary report.

We present an optimal control problem on contaminants in a river system. This application uses parabolic partial differential equations on graphs and the control is the contaminant input rate at specific locations in the river system. (Received September 17, 2012)

- 1086-35-982 **Pavel Drabek*** (pdrabek@kma.zcu.cz), Department of Mathematics and NTIS, University of West Bohemia, Univerzitni 22, 306 14 Pilsen, Czech Rep. *Continua of local minimizers in a non smooth model of phase transitions*.

In this talk we discuss the structure of critical points of the functional J which represents the total free energy in models of phase transition and allows for the study of interesting phenomena such as *slow dynamics*. In particular we consider a non-classical choice for the double-well potential F . The discontinuity in F'' at ± 1 leads to the existence of multiple continua of critical points that are not present in the classical case $F \in C^2$. We show that the interior of these continua are local minima. The energy of these local minimizers is strictly greater than the global minimum of J . In particular, the existence of these continua leads to an alternative explanation for the slow dynamics observed in phase transition models. We introduce also generalizations to the p -Laplacian equations. This is joint work with Stephen B. Robinson from Wake Forest University, Winston-Salem, N. C. (Received September 17, 2012)

- 1086-35-1012 **Guangming Yao*** (gyao@clarkson.edu), Department of Mathematics, Clarkson University, 8 Clarkson Ave, PO BOX 5815, Potsdam, NY 13699-5815. *Meshless Simulations of Space Charge Effect in Field Emission from a Nanowire*.

This paper applies localized meshless method, the local method of approximate particular solutions (LMAPS), to simulate space charge effect in field emission from a nanowire. In the past, such simulation often done by finite difference method, finite element method and other mesh-based methods. However, mesh generation or integrations on meshes are needed, which reduces efficiency of the algorithm dramatically, if it is not impossible to use such numerical techniques. LMAPS developed recently is a truly localized meshless method, in which the random nodes in even an irregular domain are the only information needed in simulations. We simulate the role of the space charge effect in the I-V behaviour of a nanowire. Our simulation results have been compared with results from ANSYS, which have shown efficiency and accuracy of meshless method. (Received September 18, 2012)

- 1086-35-1038 **Andrew Getz*** (agetz@njcu.edu), 32 Carlton Street South, Edison, NJ 08837, **Yi Ding** (yding@njcu.edu), 2039 Kennedy Blvd, Jersey City, NJ 07305, and **Zhixiong Chen** (zchen@njcu.edu), 2039 Kennedy Boulevard, Jersey City, NJ 07305. *Effects of wildfire smoke and fog on highway visibility as shown by a mathematical model*. Preliminary report.

We modeled the transportation of smoke particles from a wildfire and the presence of fog particles on a highway to determine the degree of decreased visibility for automobile drivers. Accidental wildfires and prescribed burns produce large PM_{2.5}(smoke particle) concentrations that travel to highways and lead to major motor vehicle accidents as a result of driver impairment, especially when fog exists. We studied the concentration of PM_{2.5} and fog particles in the driving view of automobiles on the highway by using numerical and analytic methods to solve diffusion-advection partial differential equations. The final concentration of smoke and fog particles after a period of wildfire burning was compared to a visibility range chart to determine the level of visual impairment for drivers on the highway. (Received September 18, 2012)

- 1086-35-1064 **B P Belinskiy** (boris-belinskiy@utc.edu), Department of Mathematics, Dept. 6956, 615 McCallie Ave., Chattanooga, TN 37403-2598, and **J V Matthews*** (matt-matthews@utc.edu), 615 McCallie Ave., Department of Mathematics, Dept. 6956, Chattanooga, TN 37403-2598. *Dynamical Inverse Problem on a Metric Tree*. Preliminary report.

We consider the problem of reconstruction of the potential for the wave equation on a star graph using the dynamical Dirichlet-to-Neumann map. Our algorithm is based on the Boundary Control method. We reduce the problem of reconstruction to a second kind Fredholm integral equation, the kernel and the right-hand-side of which arise from an auxiliary second kind Volterra integral equation. A second-order accurate numerical method for the equations is described and implemented. Then several numerical examples demonstrate that the algorithm works and can be used to reconstruct an unknown potential accurately. (Received September 18, 2012)

- 1086-35-1118 **Hans G. Kaper*** (kaper@mathclimate.org), 3335 Reservoir Rd, NW, Washington, DC 20007. *A reaction-diffusion model of the ice-albedo feedback mechanism*.

The ice-albedo feedback is an example of a positive feedback mechanism in the Earth's climate system. It arises when the polar regions of the Earth are covered with snow and ice and the equatorial region and lower latitudes are ice-free, and is a consequence of the fact that the albedo (the fraction of the solar energy reflected back into space) is much higher for snow and ice than for open water and soil. The ice-albedo feedback mechanism can be modeled by a reaction-diffusion equation for the average surface temperature in a latitudinal zone around the globe. An expansion of the temperature in a series of Legendre polynomials shows that the reaction-diffusion equation is equivalent to an infinite-dimensional dynamical system. By introducing the concept of a moving *ice line*—the line separating the ice-free lower latitudes from the ice-covered higher latitudes—and assuming that the dynamics of the ice line proceed on a much slower time scale than the dynamics of the zonally averaged surface temperature, we reduce the model to a fast-slow dynamical system. Assuming symmetry about the equator, we show that, to lowest order, this system yields a temperature profile that matches the freezing temperature of salt water (-10°C) at latitude 72.6° . (Received September 19, 2012)

- 1086-35-1121 **Junping Shi*** (jxshix@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187-8795, and **Jun Zhou**. *Advection-Reaction-Diffusion System from Ecological Models*.

Complex spatiotemporal patterns in landscape scale have been found in various ecosystems, such as spotted, striped and labyrinth vegetation patterns in semi-arid environment, and self-organized cluster patterns in mussel bed. Mathematical models of a nonlinear advection equation coupled with a nonlinear diffusion equation have been proposed for these pattern formation phenomena. We show that such systems are well posed with periodic boundary conditions, and Hopf bifurcations can generate time-periodic spatial patterns. (Received September 19, 2012)

- 1086-35-1171 **Igor Yanovsky***, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109. *Image Analysis in Remote Sensing Science*. Preliminary report.

Applications arising in remote sensing science, and computational approaches for solving associated problems, will be discussed. Among problems considered will be decomposition of layers of reflective surfaces in earth remote sensing imaging data and reconstruction of hurricane images. (Received September 19, 2012)

- 1086-35-1182 **Jennifer Beichman*** (jbeich@umich.edu). *New decay estimates for a class of 1D dispersive PDE and applications to the 2D water wave problem*. Preliminary report.

The water wave problem in 2D reduces to a 1D problem on the interface which acts like a dispersive PDE in some sense. From this starting point, I will present joint work with Sijue Wu deriving decay estimates for a class of 1D dispersive PDE including the water wave case, with precise applications to the existence for the solutions of the 2D water wave problem. (Received September 19, 2012)

- 1086-35-1218 **Shimao Fan*** (tub00072@temple.edu), 1850 N board street, Philadelphia, PA 19122. *A Generalized Aw-Rascle-Zhang Model Fitted with Historical Traffic Data*.

The Aw-Rascle-Zhang (ARZ) model is a second order macroscopic traffic model that possesses a family of fundamental diagram curves, rather than a single one as in the first order Lighthill-Whitham-Richards (LWR) model. Hence, the ARZ model can agree better with historical fundamental diagram data, especially during congested traffic. However, the ARZ model also has some obvious shortcomings, e.g., it possesses various maximum traffic densities. To overcome these drawbacks, we consider a Generalized ARZ model (GARZ), fitted

to historic traffic data. We have applied the Discontinuous Galerkin (DG) methods to solve the hyperbolic conservation system numerically. To investigate to which extent the GARZ model improves the prediction accuracy of models, we perform a comparison of data-fitted GARZ with two types of data-fitted LWR models and their second order ARZ generalizations, via a three-detector problem test. We consider two different kinds of traffic data during model construction and validation: detector data and vehicle trajectory data. Moreover, a relaxation term is added to the momentum equation of the GARZ model to overcome some unrealistic aspects of the homogeneous models. Computational results reveal on which time scales drivers actually adjust their driving behavior. (Received September 20, 2012)

1086-35-1228 **Dionyssis Mantzavinos***, mantzavinos.1@nd.edu. *The initial-boundary value problem for a class of evolution equations.*

A novel, unified approach to the solution of initial-boundary value problems for linear as well as nonlinear PDEs was introduced by Fokas in 1997. We shall use this approach to study the initial-boundary value problem for a certain class of evolution equations. (Received September 20, 2012)

1086-35-1263 **John A Helms*** (johnhelms@math.ucsb.edu), Department of Mathematics, South Hall, Room 6607, University of California, Santa Barbara, CA 93106-3080, and **Jason L Metcalfe**. *The Lifespan of Solutions to the Wave Equation in Exterior Domains.*

In this talk, we will discuss lifespans of solutions to quasilinear wave equations of the form $(\partial_t^2 - \Delta)u = Q(u, u', u'')$ whose domain is $[0, T] \times \mathbb{R}^3 \setminus \mathcal{K}$, where \mathcal{K} is a smooth, bounded domain. Previous results have shown that longtime existence of solutions follows when \mathcal{K} is star-shaped. We will see that this result extends to more general geometries. In particular, we only assume that the local energy near \mathcal{K} decays sufficiently rapidly for specific solutions to the linear wave equation. This is joint work with Professor Jason Metcalfe, UNC-Chapel Hill. (Received September 20, 2012)

1086-35-1270 **Guillaume Bal***, gb2030@columbia.edu. *Hybrid inverse problems and redundant systems of partial differential equations.*

Medical imaging modalities are most useful when they combine high resolution with high contrast. Hybrid modalities, also called coupled-physics or multi-wave modalities, satisfy this constraint by using the physical coupling between a high-contrast, low-resolution modality and a high-resolution, low-contrast modality.

Mathematically, these modalities involve in a first step, not considered in this talk, the resolution of a classical high-resolution boundary value inverse problem, and in a second step, the quantitative reconstruction of parameters of interest from the internal functionals obtained in the first step.

In several settings, the second step may be recast as a redundant system of partial differential equations. Depending on the redundancy in the system, which is related to the amount of acquired measurements, we aim to answer the following questions: (i) are the parameters of interest uniquely characterized by available measurements? (ii) are reconstructions stable with respect to errors in the measurements? (iii) are explicit reconstruction procedures available? (Received September 20, 2012)

1086-35-1277 **Samuel Walsh*** (walsh@cims.nyu.edu). *Steady water waves with compactly supported vorticity.*

In this talk, we shall discuss some recent results on the existence of two-dimensional, traveling, water waves with the special property that the vorticity is a Dirac measure (a point vortex), or supported in a compact set (a vortical patch). Such waves arise naturally, for instance, if we think of a classical, irrotational traveling wave with some interesting but localized dynamics below the surface.

This is joint work with C. Zeng (Georgia Tech) and J. Shatah (Courant). (Received September 20, 2012)

1086-35-1278 **N. Benjamin Murphy** and **Kenneth M. Golden*** (golden@math.utah.edu), University of Utah, Department of Mathematics, 155 S 1400 E, Rm. 233, Salt Lake City, UT 84112-0090. *Random Matrices, Spectral Measures, and Composite Media.*

We consider disordered heterogeneous media which arise in a broad range of applications and display structure on many length scales. Examples include random resistor networks, porous bone, the brine microstructure of sea ice, ocean eddy fields, melt ponds on the surface of Arctic sea ice, and the polar ice packs themselves. The analytic continuation method provides a rigorous approach to treating the effective properties of such systems. At the heart of this method is a random matrix which depends only on the composite geometry. In this lecture we will discuss computations of the spectral measures of this operator which yield effective transport properties, as well as statistical measures of its eigenvalues. In particular, the effective properties often exhibit large changes associated with transitions in the connectedness of a particular phase. These transitions are reflected in the behavior of the spectral measures and in the long and short range correlations of the eigenvalues of the

underlying random matrices. In the case of sea ice, these results provide greater insight into the polar marine environment and the role of sea ice in climate change. (Received September 20, 2012)

1086-35-1303 **Terrance L Pendleton*** (tlpendle@ncsu.edu), NCSU Box 8205, Raleigh, NC 27606, and **Alina Chertock** and **Jian-Guo Liu**. *Convergence of A Particle Method and Global Weak Solutions of a Family of Evolutionary PDEs.*

The purpose of this paper is to provide global existence and uniqueness results for a family of fluid transport equations by establishing convergence results for the particle method applied to these equations. The considered family of PDEs is a collection of strongly nonlinear equations which yield traveling wave solutions and can be used to model a variety of flows in fluid dynamics. We apply a particle method to the studied evolutionary equations and provide a new selfcontained method for proving its convergence. The latter is accomplished by using the concept of space-time bounded variation and the associated compactness properties. From this result, we prove the existence of a unique global weak solution in some special cases and obtain stronger regularity properties of the solution than previously established. (Received September 21, 2012)

1086-35-1340 **Milena Stanislavova***, Department of Mathematics, University of Kansas, 405, Snow Hall, Lawrence, KS 66045. *Stability of traveling waves in two water wave models.*

We consider the linear stability of traveling wave solutions for the subsonic waves in the Benney-Luke equation and the Boussinesq 'abc' system. We use two recently developed abstract stability criteria to provide a complete rigorous characterization of the linear stability and instability regions. We discuss the applicability of each tool for certain types of equations. (Received September 21, 2012)

1086-35-1508 **Kubrom Teka*** (kubrom.teka@oswego.edu), Mathematics Department, 217 Snygg Hall, SUNY Oswego, Oswego, NY 13126, and **Ivan Blank**. *Nondivergence form elliptic obstacle problem with VMO principal coefficients.*

We study the obstacle problem with an elliptic operator in nondivergence form with principal coefficients in VMO. We develop all of the basic theory of existence, uniqueness, optimal regularity, and nondegeneracy of the solutions. These results, in turn, allow us to begin the study of the regularity of the free boundary, and we show existence of a nonunique blowup limits, a basic measure stability result, and a measure-theoretic version of the Caffarelli alternative. (Received September 22, 2012)

1086-35-1582 **Georg Hetzer*** (hetzege@auburn.edu), Department of Math. and Stat., 304 Parker Hall, Auburn University, Auburn, AL 36849-5310. *Reaction-Diffusion Equations from Energy Balance Climate Models.*

Energy balance climate models are simple diagnostic models which describe the evolution of a long-term mean of temperature by employing the relevant balance equations for the heat fluxes involved. The mean horizontal heat flux is approximated by a diffusion operator, and important feedback processes appear in the net radiation flux. This talk focuses on incorporating a bio-feedback into the model which leads to a reaction-diffusion equation with memory and a non-local term. (Received September 23, 2012)

1086-35-1592 **Christine S Hoffman** (hoffm621@morris.umn.edu), 950 County Road 88 SW, Alexandria, MN 56308, **Amanda Brucker*** (abrucker14@cornellcollege.edu), #1030 810 Commons Circle, Mount Vernon, IA 52314, and **Joshua Bracewell** (jb83@njit.edu) and **Trevor Vossberg** (tvossber@hawk.iit.edu). *Nonlocal Models in Diffusion with Applications in Peridynamics.* Preliminary report.

Our work presents some nonlocal diffusion models connected with the new theory of peridynamics (introduced by Silling). Peridynamics is an alternative to continuum mechanics that allows us to model phenomena involving material discontinuities. We show connections between classical differential operators and their nonlocal counterparts, obtaining convergence results for the solutions from different points of view. We derive nonlinear diffusion equations in the nonlocal framework of peridynamics, following the ideas of Bobaru and Duangpanya. For the case when the conductivity is time dependent we derive a fundamental solution for the nonlocal problems and prove exponential decay rates by using energy methods and a nonlocal version of the Poincaré's inequality. The numerical simulations presented show estimates for the solution in the nonlinear case as well as in the case of time dependent conductivity.

(Received September 23, 2012)

1086-35-1642 **John C Schotland*** (schotland@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *Inverse Problem of Acousto-Optic Imaging.*

A method to reconstruct the optical properties of a highly-scattering medium from acousto-optic measurements is proposed. The method is based on the solution to an inverse problem for the diffusion equation and makes use of the principle of interior control of boundary measurements by an external wave field. (Received September 23, 2012)

1086-35-1675 **Eun Kyoung Lee*** (eunkyoung165@gmail.com), **Seong-Uk Kim** and **Yong-Hoon Lee**. *Three solutions theorem for radial solution of p -Laplacian problem on Exterior domain.*

This is a joint work with Seong-Uk Kim and Yong-Hoon Lee. In this talk, we prove the three solutions theorem for p -Laplacian ordinary differential problem with singular weight function. This theorem can explain the three solutions theorem for corresponding radial solutions on exterior domain. To prove this theorem, we compute the Leray-Schauder Degree on new weighted solution space. This theorem can be applied to the combustion model to show the existence of three positive radial solutions on exterior domain. (Received September 24, 2012)

1086-35-1710 **Daniele Garrisi*** (daniele.garrisi@gmail.com), Nam-Gu, Inha University, Department of Mathematics Education (444), Incheon, Incheon 402-751. *Orbital stability of standing-waves by means of the symmetric rearrangement.*

Very often, in literature the orbital stability of standing-wave solutions to evolution problems (such as the non-linear Schrödinger equation and the non-linear wave equation) is proven by showing the existence of a minimizer to a suitably chosen variational problem

$$I(\lambda) = \inf_{S(\lambda)} J$$

and that I satisfies the sub-additivity property, that is

$$I(\lambda) < I(\lambda_1) + I(\lambda_2), \quad \lambda = \lambda_1 + \lambda_2.$$

Such inequality is known to rule out the dichotomic case in the Concentration-Compactness Lemma of P. L. Lions. The inequality is achieved by a rescaling argument in the scalar case, or by exploiting the symmetry of the non-linear term for systems of non-linear equations. We propose an approach to the sub-additivity property which exploits the properties of the symmetric rearrangement. We show, in particular, that standing-wave solutions to a coupled system of non-linear Klein-Gordon equations

$$v_{tt}^j - \Delta_x v_j + m_j^2 v_j + \partial_j F(v) = 0, \quad 1 \leq j \leq 2$$

are orbitally stable. An example of the non-linearity we have in mind is

$$F(z) = -|z_1 z_2|^p + G(z_1, z_2), \quad 2F + \sum_{j=1}^2 m_j^2 z_j^2 \geq 0.$$

(Received September 25, 2012)

1086-35-1726 **Shari Moskow*** (moskow@math.drexel.edu) and **Guillaume Bal**. *Local inversions in ultrasound modulated optical tomography.*

We consider the problem of the simultaneous recovery of both the absorption and diffusion coefficients with internal data in a form that is of power density type. We assume we have some known background coefficients, and examine the corresponding linearized problem. This linearized problem can be expressed as a fourth order system, and we examine its stability and injectivity properties. (Received September 24, 2012)

1086-35-1729 **Julian K Edward*** (edwardj@fiu.edu), Department of Mathematics, Florida International University, Miami, FL 33199. *Inverse problems for strings with attached masses.* Preliminary report.

We consider the inverse problems associated to the following two systems:

(i) for a string loaded by several masses and (ii) for a star-graph of strings with a mass at a center. The boundary control method is used to recover the number of strings, together with their density and length, and the masses.

The talk is based on joint work with Sergei Avdonin and Nina Avdonina. (Received September 24, 2012)

1086-35-1732 **Jerome Goddard II*** (jgoddard@aum.edu) and **R. Shivaji** (shivaji@uncg.edu). *Diffusive logistic equation with negative density dependent emigration on the boundary.*

We examine the structure of positive steady state solutions for a diffusive population model with logistic growth and negative density dependent emigration on the boundary. In particular, this class of nonlinear boundary conditions depends on both the population density and the diffusion coefficient. In this presentation, we will discuss results obtained in the one-dimensional case. (Received September 24, 2012)

- 1086-35-1736 **Fabrice Baudoin, Michel Bonnefont, Nicola Garofalo and Isidro H Munive Lima*** (imunive@math.purdue.edu), 3105 Courthouse DR W APT 2B, West Lafayette, IN 47906. *Comparison Theorem for Negatively Curved Sub-Riemannian Manifolds.*

In this talk we prove a volume comparison theorem for manifolds satisfying the generalized curvature-dimension inequality introduced by Baudoin and Garofalo in the context of sub-Riemannian manifolds. In particular we establish:

- The volume doubling property;
- The Poincare inequality;
- The parabolic Harnack inequality.

The key ingredient is the study of dimensional reverse log-Sobolev inequalities for the heat semigroup and corresponding non-linear reverse Harnack type inequalities. (Received September 24, 2012)

- 1086-35-1740 **Tao Huang***, Department of Mathematics, Lexington, KY 40506, and **Changyou Wang**. *Regularity and uniqueness for a class of solutions to the hydrodynamic flow of nematic liquid crystals.*

We establish an ϵ -regularity criterion for any weak solution (u, d) to the nematic liquid crystal flow such that $(u, \nabla d) \in L_t^p L_x^q$ for some $p \geq 2$ and $q \geq n$ satisfying the condition $\frac{n}{q} + \frac{2}{p} = 1$. As consequences, we prove the interior smoothness of any such a solution when $p > 2$ and $q > n$. We also show that uniqueness holds for the class of weak solutions (u, d) the Cauchy problem of the nematic liquid crystal flow that satisfy $(u, \nabla d) \in L_t^p L_x^q$ for some $p > 2$ and $q > n$ satisfying $\frac{n}{q} + \frac{2}{p} = 1$. (Received September 24, 2012)

- 1086-35-1744 **Walter Craig*** (craig@math.mcmaster.ca), Department of Mathematics & Statistics, McMaster University, Hamilton, Ontario L8S 4K1, Canada. *Near-parallel vortex filament dynamics.*

Over the past decade and more, techniques have been developed for the phase space analysis of the dynamics of many model nonlinear Hamiltonian PDEs. In this talk I will describe some extensions of these ideas to a problem in fluid dynamics concerning the interaction of two near-parallel vortex filaments in three dimensions. In addition, as well as generalizations of this problem, I will give a number of promising directions of study and further applications of the techniques of Hamiltonian PDEs to other nonlinear systems of fluid dynamics, in the form of a class of nonlinear evolution problems of physical significance. (Received September 24, 2012)

- 1086-35-1769 **Ariel Barton*** (barto106@math.umn.edu), School of Mathematics, University of Minnesota, 206 Church Street, S.E., Minneapolis, MN 55455, and **Svitlana Mayboroda** (svitlana@math.umn.edu), School of Mathematics, University of Minnesota, 206 Church Street, S.E., Minneapolis, MN 55455. *The Dirichlet problem for higher order equations in composition form.*

In 1986, Dahlberg, Kenig and Verchota proved that unique solutions to the Dirichlet problem for the bilaplacian Δ^2 , with L^2 boundary data, exist in Lipschitz domains. After applying a change of variables, the bilaplacian Δ^2 becomes a fourth-order operator of the form $L^*(aL)$, where L is a second-order divergence-form elliptic operator and a is a scalar-valued function. We construct solutions to the Dirichlet problem for some other operators of the form $M^*(aL)$. (Received September 24, 2012)

- 1086-35-1772 **Jose Caicedo and Alfonso Castro*** (castro@g.hmc.edu), Department of Mathematics, Harvey Mudd College, Claremont, CA 91711, and **Victor Ardila**. *Singular solutions for superlinear elliptic equations.*

We show the existence of uncountably many radial singular solutions for superlinear elliptic boundary value problems including subcritical, sub-super critical, and jumping nonlinearities. The set of such solutions is unbounded. Note that in the case of jumping nonlinearities this set is compact. (Received September 24, 2012)

- 1086-35-1832 **Jerry L. Bona*** (bona@math.uic.edu), Dept. Math., Statistics & Computer Science, University of Illinois at Chicago, 851 S. Morgan Street, MC 249, Chicago, IL 60607, **Shu-Ming Sun** (sun@math.vt.edu), Department of Mathematics, Virginia Tech, 460 McBryde, Blacksburg, VA 24061, and **Bing-Yu Zhang**, Department of Mathematical Sciences, University of Cincinnati, 839 Old Chemistry, PO Box 213417, Cincinnati, OH 45221. *Non-homogeneous Boundary-Value Problems for the Schrödinger Equation.*

This lecture will deal with initial-boundary-value problems for a class of nonlinear Schrödinger equations posed on the half line and on a bounded interval. Both local and global well-posedness results will be discussed. (Received September 24, 2012)

1086-35-1869 **David M. Ambrose*** (ambrose@math.drexel.edu), 3141 Chestnut St., Philadelphia, PA 19104. *Time-Periodic and Traveling Waves in Interfacial Fluid Dynamics.*

We will discuss issues related to time-periodic and traveling waves for the vortex sheet with surface tension, and possibly for the water wave with surface tension. Results include computations of nontrivially time-periodic solutions for the full equations of motion for the vortex sheet with surface tension, and computations and proof of existence of traveling waves for the vortex sheet with surface tension (which are trivially time-periodic). Furthermore, numerical results for time-periodic solutions for a simple model system will be shown. If time permits, rigorous analysis for the simple model system will be discussed, as will traveling waves for the water wave with surface tension. This includes joint work with Jon Wilkening, Benjamin Akers, J. Douglas Wright, Mark Kondrla, Michael Valle, and possibly C. Eugene Wayne. (Received September 24, 2012)

1086-35-1882 **Ting Zhou***, Department of Mathematics, MIT, 77 Massachusetts Avenue, Building 2 office 335, Cambridge, MA 02139. *Title: Quantitative thermo-acoustics and related problems.*

Abstract: Thermo-acoustic tomography is a hybrid multi-waves medical imaging modality that aims to combine the good optical contrast observed in tissues with the good resolution properties of ultrasound. Thermo-acoustic imaging consists of two steps: first to reconstruct an amount of electromagnetic radiation absorbed by tissues by solving inverse problems of acoustic waves; secondly to quantitatively reconstruct the optical property of the tissues from the absorption (reconstructed from the first step), which is an internal functional. We are mostly interested in the second step and show some uniqueness and stability results for the full Maxwell's system models under the assumption that the parameter is small, and the uniqueness, stability and reconstruction results for the scalar model. The key ingredient in showing the second result is the complex geometric optics (CGO) solutions. (Received September 24, 2012)

1086-35-1907 **Patricia E. Bauman**, Dept. of Mathematics, Purdue University, West Lafayette, IN 47907, and **Guanying Peng*** (gpeng@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907. *Analysis of the Lawrence-Doniach Model in Perpendicular Applied Fields.* Preliminary report.

We analyze minimizers of the Lawrence-Doniach energy for layered superconductors occupying a bounded cylinder, $\Omega \times [0, L]$, in \mathbf{R}^3 , where Ω is a simply connected bounded Lipschitz domain in \mathbf{R}^2 . For an applied magnetic field $\vec{H}_{ex} = h_{ex}\vec{e}_3$ that is perpendicular to the layers where $|\ln \epsilon| \ll h_{ex} \ll \epsilon^{-2}$, we prove an asymptotic formula for the minimum Lawrence-Doniach energy as ϵ and the interlayer distance s tend to zero. Under appropriate assumptions on ϵ versus s , we establish comparison results between the minimum energies of the Lawrence-Doniach and the 3D anisotropic Ginzburg-Landau models. (Received September 24, 2012)

1086-35-1914 **Farhod Abdullayev*** (farkhad.abdullaev@nds.u.edu), 1010 12TH Ave N, Apt 5, Fargo, ND 58102. *The asymptotic behavior of solutions to the Robin eigenvalue problem for the $p(x)$ -Laplacian as $p(x) \rightarrow \infty$.*

We study the asymptotic behavior of the (first) eigenvalues and the corresponding eigenfunctions for the Robin problem for the $p(x)$ -Laplacian:

$$\begin{cases} -\Delta_{p(x)} u = \lambda |u|^{p(x)-2} u & \text{in } \Omega \\ |\nabla u|^{p(x)-2} \frac{\partial u}{\partial \eta} + \beta |u|^{p(x)-2} u = 0 & \text{on } \partial\Omega. \end{cases}$$

as $p(\cdot) \rightarrow \infty$. (Received September 24, 2012)

1086-35-1917 **Laxmi P. Paudel*** (laxmipaudel@my.unt.edu), 1701 west Oak Apt #210, Denton, TX 76201, and **Joseph Iaia**. *Title: Traveling Wave Solutions of the Porous Medium Equation.* Preliminary report.

We reduce the Porous Medium Equation (PME) into an ordinary differential equation, and prove the existence of its one parameter family of solutions. We prove that the solutions are stable under a suitable class of perturbations. In this paper, we have successfully extended the various results that J. Iaia and S. Betelu got in two dimensional PME to three dimensions. (Received September 24, 2012)

1086-35-1924 **Sergei Avdonin*** (sergei-avdonin@utc.edu), Department of Mathematics, University of Tennessee at Chattanooga, Chattanooga, TN 37403. *Inverse problems for differential equations on graphs with cycles.*

We consider spectral and dynamical inverse boundary problems for differential equations on graphs with cycles. Uniqueness results and reconstruction algorithms are discussed. (Received September 24, 2012)

1086-35-1938 **Feride Tiglay*** (feride.tiglay@gmail.com). *Well-posedness and breakdown of solutions of an asymptotic equation for liquid crystals*. Preliminary report.

We present results concerning well-posedness and breakdown of solutions to the periodic Cauchy problem of an integrable equation derived as an asymptotic model for liquid crystals. (Received September 24, 2012)

1086-35-1959 **Heather Rosenblatt*** (rosenblatt@math.ohio-state.edu), Department of Mathematics, The Ohio State University, 231 West 18th Ave, Columbus, OH 43210, and **Saleh Tanveer** (tanveer@math.ohio-state.edu), Department of Mathematics, The Ohio State University, 231 West 18th Ave, Columbus, OH 43210. *Existence, Uniqueness, Analyticity, and Borel Summability of Boussinesq and Magnetic Benard Equations*.

Through Borel summation methods, we analyze two different variations of the Navier-Stokes equation –the Boussinesq equation and the magnetic Benard equation. This method has previously been applied to the Navier-Stokes equation. We prove that an equivalent system of integral equations in each case has a unique solution, which is exponentially bounded for p in \mathbb{R}^+ , p being the Laplace dual variable of $\frac{1}{t}$. This implies the local existence of a classical solution in a complex t -region that includes a real positive time (t)-axis segment. In this formalism, global existence of PDE solutions becomes a problem of asymptotics in the dual variable. Further, it is shown that within the time interval of existence, for analytic initial data and forcing, the solution remains analytic and has the same analyticity strip width. Under these conditions, the solution is Borel summable, implying that the formal series in time is Gevrey-1 asymptotic for small t . (Received September 24, 2012)

1086-35-1976 **Alex Himonas*** (himonas.1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *On the Cauchy problem of a class of integrable equations*.

We shall discuss well-posedness and regularity properties for a class of integrable equations that include the Camassa-Holm, the Degasperis-Procesi, the Novikov and the KdV equations. (Received September 24, 2012)

1086-35-1992 **Luis Caffarelli** and **Betul Orcan-Ekmekci*** (orcan@rice.edu). *Homogenization results for Stationary Ergodic Free Boundary Problems in \mathbb{R}^2 : Elliptic Case in Layered Form*.

In this study, we present some results about a homogenization problem for the largest subsolution of a one-phase free boundary problem (FBP) which has a stationary ergodic layered free boundary in \mathbb{R}^2 . This problem is motivated by Bernoulli type FBP with nonconstant free boundary condition (FBC) on random media. For both exterior and interior Bernoulli homogenization problems, the normal vector direction of the free boundary plays an important role for the limit and this study, which can be considered as the "planary" version problem, enables us to understand the asymptotic behavior of the free boundary in the limit. (Received September 24, 2012)

1086-35-2030 **Thomas Nagylaki** and **Linlin Su*** (lsu@wpi.edu), Department of Mathematical Sciences, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609, and **Kai Zeng**. *Clines With Partial Panmixia: Environmental Pockets And Complete Dominance*. Preliminary report.

In geographically structured populations, global panmixia (i.e., random mating) can be regarded as the limiting case of long-distance migration. The effect of incorporating partial panmixia into diallelic single-locus clines maintained by migration and selection is investigated in two cases: (i) an isotropic environmental pocket in n dimensions and (ii) complete dominance in an unbounded unidimensional habitat. Migration and selection are both weak. The former is homogeneous and isotropic; the latter is directional. In case (i), if the scaled panmictic rate $\beta \geq 1$, then the allele favored in the pocket is ultimately lost. For $\beta < 1$, a cline is maintained if and only if the radius a of the pocket exceeds a critical value a_n . In case (ii), a cline always exists if $\alpha = 1$, where α denotes the ratio of the selection coefficient favoring the dominant allele to that favoring the recessive. For a step-environment and $\alpha \neq 1$, a unique cline exists if and only if β is less than a critical value. If $\alpha > 1$ and $\beta > 0$, a smaller, unique unstable equilibrium also exists whenever the cline does. If $\beta > 0$, some genetic variation is maintained even infinitely far from the center of the cline. (Received September 24, 2012)

1086-35-2043 **E N Barron**, **R Goebel** and **R R Jensen*** (rjensen@luc.edu). *Quasiconvexity, Nonlinear PDEs, and Principal Curvature*.

In this talk I will present joint work on a second order characterization of functions which have convex level sets (quasiconvex functions). This leads to a discontinuous, nonlinear degenerate, elliptic operator $L_0(Du, D^2u)$. In two dimensions it is the mean curvature operator; and in higher dimensions it is the first principal curvature operator of the surfaces $S = u^{-1}(c)$. Our main results include a comparison principle for $L_0(Du, D^2u) = g$ when $g \geq C_g > 0$ and a comparison principle for quasiconvex solutions of $L_0(Du, D^2u) = g$ when $g \geq 0$. We also consider a continuous version of L_0 , $L_\alpha(Du, D^2u)$, which characterizes α -robustly quasiconvex functions - i.e., functions which remain quasiconvex under small linear perturbations. A comparison principle is proved for

L_α ; and approximation of quasiconvex functions by α -robustly quasiconvex functions is established. (Received September 24, 2012)

1086-35-2086 **Yue Chen** and **Robert Lipton*** (lipton@math.lsu.edu). *Dispersion relations for double negative metamaterials.*

Metamaterials with frequency dependent double negative effective properties are constructed from sub-wavelength periodic arrays of coated inclusions. Power series are developed for the dispersion relation and the associated Bloch wave solutions. The expansion parameter is the ratio of the length scale of the periodic lattice to the wavelength. Numerical simulations show that the leading order term in the power series for the dispersion relation is a good predictor of the dispersive behavior of the metamaterial. (Received September 24, 2012)

1086-35-2142 **Florian Maris*** (fmaris@math.uh.edu), 5514 Griggs, # 230, Houston, TX. *Random homogenization for solid suspensions in a fluid.* Preliminary report.

We derive effective properties for a randomly suspension of solid particles in a viscous fluid. (Received September 24, 2012)

1086-35-2161 **Steve Shkoller*** (shkoller@math.ucdavis.edu), Department of Mathematics, University of California at Davis, Davis, CA 95616. *On the finite-time splash and splat singularities for the 3-D free-surface Euler equations.*

We prove that the 3-D free-surface incompressible Euler equations with regular initial geometries and velocity fields have solutions which can form a finite-time "splash" (or "splat") singularity, wherein the evolving 2-D hypersurface, the moving boundary of the fluid domain, self-intersects at a point (or on surface). Such singularities can occur when the crest of a breaking wave falls unto its trough, or in the study of drop impact upon liquid surfaces. Our approach is founded upon the Lagrangian description of the free-boundary problem, combined with a novel approximation scheme of a finite collection of local coordinate charts; as such we are able to analyze a rather general set of geometries for the evolving 2-D free-surface of the fluid. We do not assume the fluid is irrotational, and as such, our method can be used for a number of other fluid interface problems, including compressible flows, plasmas, as well as the inclusion of surface tension effects. This is joint work with D. Coutand. (Received September 24, 2012)

1086-35-2189 **Jeffrey J Langford*** (jeff.langford@drake.edu), Des Moines, IA 50311. *Symmetrization of Poisson's Equation with Neumann Boundary Conditions.*

In this talk we prove isoperimetric-type inequalities for solutions of Poisson's equation using rearrangement methods. Specifically, among all functions f with fixed "size", we identify those which admit "biggest" solutions to the Poisson PDE

$$-\Delta u = f \quad \text{in } \Omega, \quad \frac{\partial u}{\partial n} = 0 \quad \text{on } \partial\Omega.$$

Here, we use the term "biggest" to mean those functions which exhibit largest convex means. We prove such isoperimetric-type results when Ω is a spherical shell, a sphere, and a hemisphere. As a corollary, we prove a conjecture of B. Kawohl from the mid 1980s. (Received September 25, 2012)

1086-35-2206 **Mihaela Ignatova***, Department of Mathematics, building 380, Stanford, CA 94305, and **Igor Kukavica**, **Irena Lasiecka** and **Amjad Tuffaha**. *On well-posedness and small data global existence for a damped free boundary fluid-structure model.*

We address a fluid-structure interaction model describing the motion of an elastic body in an incompressible fluid. We prove the local existence of solutions for a class of initial data which also guarantees uniqueness. Our second main result provides the global existence and exponential decay of solutions for a model with frictional damping.

This is a joint work with Igor Kukavica, Irena Lasiecka, and Amjad Tuffaha (Received September 25, 2012)

1086-35-2251 **Soohyun Bae*** (shbae@hanbat.ac.kr), Faculty of Liberal Arts and Sciences, 125 Dongseodae-ro, Yuseong-gu, Daejeon, 305-719. *Asymptotic self-similarity in semilinear elliptic equations.*

Scale invariance in semilinear elliptic equations plays important roles in studying solution structure. It is natural to look for a self-similar solution which is invariant under the scaling. In general, asymptotic self-similarity is a useful viewpoint to understand the existence and the asymptotic behavior of solutions. In this talk I give a survey on the subject and discuss related topics. (Received September 25, 2012)

- 1086-35-2279 **Xiang-Sheng Wang*** (xswang@mun.ca), Dept of Math & Stat, Memorial University of Newfoundland, St. John's, NL A1C 5S7, Canada. *Traveling Waves of Diffusive Predator-Prey Systems: Disease Outbreak Propagation*. Preliminary report.

We study the traveling waves of reaction-diffusion equations for a diffusive SIR model. The existence of traveling waves is determined by the basic reproduction number of the corresponding ordinary differential equations and the minimal wave speed. Our proof is based on Schauder fixed point theorem and Laplace transform. (Received September 25, 2012)

- 1086-35-2285 **Stephen B Robinson*** (sbr@wfu.edu), **Pavel Drabek** and **Quinn Morris**. *Resonance results on the Fucik Spectrum*.

Consider the problem

$$-\Delta u = au^+ - bu^- + g(u) + h, \text{ in } \Omega$$

$$u|_{\partial\Omega} = 0,$$

where Ω is a smooth bounded domain, $g(u)$ is a continuous function satisfying a sublinear growth condition, $h \in L^2(\Omega)$, and (a, b) is a pair of real numbers on the well-known Fucik Spectrum, Σ . Building upon a recent variational characterization of Σ due to Castro and Chang, we prove the existence of at least one weak solution subject to a generalized Landesman-Lazer condition. The proof applies linking theory and characterizes the solution as a saddle point. We also indicate how our results generalize to a broader class of quasilinear problems. (Received September 25, 2012)

- 1086-35-2320 **Henok Mawi*** (henok.mawi@howard.edu). *Regularity Properties of Solutions of a Higher Order Free Boundary Problem*. Preliminary report.

Let Ω be a domain in \mathbf{R}^n with $0 \in \partial\Omega$. Suppose in B , the unit ball in \mathbf{R}^n , u and Ω satisfy the following equation in the sense of distributions:

$$Lu = \chi_\Omega \text{ in } B$$

$$D^\alpha u = 0 \text{ for } |\alpha| \leq 3 \text{ in } B \setminus \Omega.$$

Here L is a homogeneous fourth order elliptic operator and χ_Ω denotes the characteristic function.

We analyze the regularity properties of u . (Received September 25, 2012)

- 1086-35-2329 **Netra Khanal*** (nkhanal@ut.edu), 401 W. Kennedy Blvd, Tampa, FL 33620, and **Jiahong Wu** and **Juan-Ming Yuan**. *Fifth-order complex Korteweg-de Vries type equations*.

This talk focuses on spatially periodic complex-valued solutions of the fifth-order Korteweg-de Vries (KdV) type equations. The aim is at several fundamental issues including the existence, uniqueness and finite-time blowup problems. Special attention is paid to the Kawahara equation, a fifth-order KdV type equation. When a Burgers dissipation is attached to the Kawahara equation, we establish the existence and uniqueness of the Fourier series solution with the Fourier modes decaying algebraically in terms of the wave numbers. We also examine a special series solution to the Kawahara equation and prove the convergence and global regularity of such solutions associated with a single mode initial data. In addition, finite time blow-up results are discussed for the special series solution of the Kawahara equation. (Received September 25, 2012)

- 1086-35-2367 **Melissa Davidson*** (mdavids4@nd.edu), 255 Hurley, Department of Mathematics, Notre Dame, IN 46556. *Continuity Properties of the Solution Map for the Generalized Reduced Ostrovsky Equation*.

It is shown that the data-to-solution map for the generalized reduced Ostrovsky (gRO) equation is not uniformly continuous on bounded sets in Sobolev spaces on the circle with exponent $s > 3/2$. Considering that for this range of exponents the gRO equation is well-posed with continuous dependence on initial data, this result makes the continuity of the solution map an optimal property. However, if a weaker H^r -topology is used then it is shown that the solution map becomes Hölder continuous in H^s . (Received September 25, 2012)

- 1086-35-2398 **Murat Akman*** (makman@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40508, and **John L. Lewis**, Department of Mathematics, University of Kentucky, Lexington, KY 40508. *On the Dimension of a Certain Measure Arising From a PDE*. Preliminary report.

In this paper we study the Hausdorff dimension of a measure μ related to a positive weak solution, u , of a certain partial differential equation in $\Omega \cap N$ where $\Omega \subset \mathbb{C}$ is bounded simply connected domain and N is neighborhood

of $\partial\Omega$, u has continuous boundary value 0 on $\partial\Omega$ and is a weak solution to

$$\sum_{i,j=1}^2 \frac{\partial}{\partial x_i} (f_{\eta_i \eta_j}(\nabla u(z)) u_{x_j}(z)) = 0 \text{ in } \Omega \cap N.$$

Also $f(\eta)$, $\eta \in \mathbb{C}$ is homogeneous of degree p and ∇f is δ -monotone on \mathbb{C} for some $\delta > 0$. Put $u \equiv 0$ in $N \setminus \Omega$. Then μ is the unique positive finite Borel measure μ with support in $\partial\Omega$ satisfying

$$\int_{\mathbb{C}} \langle \nabla f(\nabla u(z)), \nabla \phi(z) \rangle dA = - \int_{\partial\Omega} \phi(z) d\mu$$

for every $\phi \in C_0^\infty(N)$.

Our work generalizes work of Lewis and coauthors when the above PDE is the p Laplacian (i.e, $f(\eta) = |\eta|^p$) and also for $p = 2$, the well known theorem of Makarov regarding the Hausdorff dimension of harmonic measure relative to a point in Ω . (Received September 26, 2012)

1086-35-2418 **Donna S. Stutson*** (dstutson@xula.edu). *A Numerical Example for the One Dimensional Caputo Fractional Wave Equation using the Representative Solution and the Generalized Monotone Method.*

A numerical example for the one dimensional Caputo fractional wave equation is presented. This numerical example requires the use of a representative formula for the one dimensional Caputo fractional wave equation along with the generalized monotone method for this equation. (Received September 25, 2012)

1086-35-2419 **Maya Chhetri*** (maya@uncg.edu), **Pavel Drabek** (pdrabek@kma.zcu.cz) and **R. Shivaji** (shivaji@uncg.edu). *Positive solutions for a class of p -Laplacian superlinear semipositone problems.*

We consider an elliptic problem of the form

$$\left. \begin{aligned} -\Delta_p u &= \lambda f(u) & \text{in } \Omega \\ u &> 0 & \text{in } \Omega \\ u &= 0 & \text{on } \partial\Omega, \end{aligned} \right\}$$

where $\lambda > 0$ is a parameter, Ω is a strictly convex bounded domain in R^N ; $N \geq 2$ with C^2 boundary $\partial\Omega$ and $1 < p \leq 2$. The nonlinearity $f : [0, \infty) \rightarrow R$ is a continuous function that is semipositone ($f(0) < 0$) and p -superlinear at infinity. We use degree theory combined with re-scaling argument and uniform L^∞ apriori estimate to prove that the problem has a positive solution for λ small. We extend this result to systems case as well. (Received September 25, 2012)

1086-35-2545 **Hongqiu Chen*** (hchen1@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152. *Initial-boundary value problem for coupled dispersive equations.*

Considered here are systems of equations of BBM type, viz.

$$\begin{cases} \partial_t u + u_x - \partial_{xx} u + \partial_x (Au^2 + Buv + Cv^2) = 0, \\ \partial_t v + v_x - \partial_{xx} v + \partial_x (Du^2 + Euv + Fv^2) = 0 \end{cases}$$

where $u = u(x, t)$ and $v = v(x, t)$ are real valued functions for $x \in I, t \geq 0$, where $I \subset \mathbb{R}$ can be bounded interval, half line and \mathbb{R} itself, (of course with appropriate initial-boundary conditions), A, B, \dots, F are real constants. Theory regarding well-posedness in this case is a little more subtle than in the case of a single equation. (Received September 25, 2012)

1086-35-2554 **Matthew Pennybacker*** (pennybacker@math.arizona.edu), 617 N. Santa Rita Ave., P.O. Box 210089, Tucson, AZ 85721-0089, and **Alan C Newell**. *Nonlinear Fronts in the Swift-Hohenberg Equation as a Model for Phyllotaxis.*

Phyllotaxis, or the regular arrangement of plant structures, is among the most striking of natural phenomena. Perhaps the best example of this is found among the seeds on the head of a sunflower. Counting the number of spirals in the clockwise and counter-clockwise directions at the outer edge of the head often yields two consecutive members of the Fibonacci sequence, and moving inward, a transition to smaller Fibonacci numbers.

We have recently developed a model for phyllotaxis based on the Swift-Hohenberg equation, a PDE describing a broad class of pattern-forming systems. In this work, we demonstrate how phyllotactic patterns may be realized as a nonlinear pushed front solution to this model, including the transition rule that results in the Fibonacci sequence, and compare our results to those of previous geometric and discrete models of phyllotaxis. (Received September 25, 2012)

- 1086-35-2561 **A Castro, Eunkyung Ko and R Shivaji*** (shivaji@uncg.edu), Dept of Mathematics & Statistics, University of North Carolina at Greensboro, 116 Petty Building, 317 College Ave, Greensboro, NC 27412. *A uniqueness result for a singular nonlinear eigenvalue problem.*

We consider positive solutions to singular boundary value problems of the form

$$\begin{cases} -\Delta u = \lambda \frac{f(u)}{u^\beta} & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

where $\lambda > 0$, $\beta \in (0, 1)$ and Ω is a bounded domain \mathbb{R}^N , $N \geq 1$ with a smooth boundary $\partial\Omega$. Here we assume that $f \in C^1([0, \infty), (0, \infty))$ is nondecreasing and $\frac{f(s)}{s^\beta}$ is decreasing for s large. We establish the uniqueness of the positive solution when λ is large. (Received September 25, 2012)

- 1086-35-2571 **Danny Arrigo*** (darrigo@uca.edu), Department of Mathematics, 201 Donaghey Ave., Conway, AR, and **Brandon Ashley and Thomas Deatherage.** *Hopf-Cole Type Transformations for a Viscous Burgers Equation.*

It is well known that solutions of the linear heat equation can be used to generate solutions of Burgers equation through the Hopf-Cole transformation. Recently it has been shown that a Hopf-Cole type transformation exists such that solutions of the fast diffusion equation can be used to generate solutions of a viscous Burgers equation. In this talk we show that this result generalizes. We present results showing that there exists large classes of Hopf-Cole type transformations where solution of nonlinear diffusion equations gives rise to solutions of viscous Burgers equations. (Received September 25, 2012)

- 1086-35-2601 **Ryan Szypowski*** (rsszypowski@csupomona.edu), 3801 West Temple Ave, Pomona, CA 91768, and **Mike Holst and Andrew Gillette.** *Adaptive FEEC for Nonlinear Geometric PDEs.* Preliminary report.

The adaptive finite element method, based on the standard SOLVE \rightarrow ESTIMATE \rightarrow MARK \rightarrow REFINES loop, is well understood for standard finite element approximations of general nonlinear PDEs satisfying appropriate assumptions on the nonlinearity. In this talk, we will present some early numerical and analytic results for incorporating this same approach to adaptivity to the finite element exterior calculus framework. This framework is developed for the approximation of solutions to PDEs defined in the context of a Hilbert complex, and is useful in understanding many PDEs with geometric underpinnings. Here, we will mostly restrict our attention to the Hodge-Laplacian defined on a smooth 2-surface as our model problem. The development is based on results for adaptive finite element approximations applied to a mixed method for the standard Laplace equation. (Received September 25, 2012)

- 1086-35-2615 **Michael E Filippakis*** (mfilip@unipi.gr), University of Piraeus, Department of Digital, Systems, 80 Karaoli and dimitriou Str. Piraeus, 18534, 18534 Piraeus, Greece, and **Nikolaos S Papageorgiou** (npapg@math.ntua.gr), Department of Mathematics, NTUA, Zografou Campus, Athens, Greece, 15780, 15780 Athens, Greece. *Existence of Nodal solutions for Neumann nonlinear differential equations driven by p-Laplacian equations.* Preliminary report.

We consider Neumann nonlinear differential equations driven by the p-Laplacian with a nonsmooth potential and we use techniques from Morse Theory and nonlinear analysis in order to prove the existence of nodal solutions. Our approach uses nonsmooth critical point theory, Morse Theory coupled with the method of upper and lower solutions. (Received September 25, 2012)

- 1086-35-2701 **Qinghua Luo*** (qluo93@marianuniversity.edu). *Identification Problem for the Damped Nonlinear Klein-Gordon Equation.* Preliminary report.

We study the identification problems for the damped nonlinear Klein-Gordon equation. In particular, we consider the equation with a variable diffusion coefficient as follows.

$$u_{tt}(t, x) + \alpha u_t(t, x) - \nabla(\beta(x) \nabla u(t, x)) + \delta g(u(t, x)) = f(t, x)$$

where the diffusion coefficient $\beta(x)$ is Lipschitz continuous. We prove the existence of the optimal parameter and derive the necessary conditions on the optimal parameters. (Received September 25, 2012)

- 1086-35-2769 **Scott Armstrong and Charles K Smart*** (smart@math.mit.edu). *Regularity and stochastic homogenization of fully nonlinear equations without uniform ellipticity.*

We prove regularity and stochastic homogenization results for certain degenerate elliptic equations in nondivergence form. The equation is required to be strictly elliptic, but the ellipticity may oscillate on the microscopic scale and is only assumed to have a finite d th moment, where d is the dimension. Showing that such an equation behaves like a uniformly elliptic equation requires a novel reworking of the regularity theory. We prove

deterministic estimates depending on averaged quantities involving the distribution of the ellipticity, which are controlled in the macroscopic limit by the ergodic theorem. We show that the moment condition is sharp by giving an explicit example of an equation whose ellipticity has a finite p th moment, for every $p < d$, but for which regularity and homogenization break down. (Received September 25, 2012)

1086-35-2811 **Constance M Schober*** (constance.schober@ucf.edu), University of Central Florida, Dept. of Mathematics, P.O. Box 161364, Orlando, FL 32816-1364, and **Annalisa Calini**. *Dynamical Criteria for Rogue Waves in Nonlinear Schrodinger Models.*

We investigate rogue waves in deep water in the framework of the nonlinear Schrodinger (NLS) and Dysthe equations. Amongst the homoclinic orbits of unstable NLS Stokes waves, we seek good candidates to model actual rogue waves. In this article we propose two selection criteria: stability under perturbations of initial data, and persistence under perturbations of the NLS model. We find that requiring stability selects homoclinic orbits of maximal dimension. Persistence under (a particular) perturbation selects a homoclinic orbit of maximal dimension all of whose spatial modes are coalesced. These results suggest that more realistic sea states, described by JONSWAP power spectra, may be analyzed in terms of proximity to NLS homoclinic data. In fact, using the NLS spectral theory, we find that rogue wave events in random oceanic sea states are well predicted by proximity to homoclinic data of the NLS equation. (Received September 25, 2012)

1086-35-2849 **Yuliya Gorb*** (gorb@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204, and **Lilliana Borcea** and **Yingpei Wang**. *Discrete Network Approximation for Dirichlet-to-Neumann Map for High Contrast Problems.*

A model of a composite material consisting of a matrix of finite conductivity with ideally conducting almost touching particles is considered, and a discrete network approximation for the Dirichlet-to-Neumann map is constructed and justified. (Received September 25, 2012)

1086-35-2870 **Xiaodong Cao** (cao@math.cornell.edu), **Bowei Liu** (boweiliu@princeton.edu), **Ian Pendleton*** (ian.pend@berkeley.edu) and **Abigail Ward** (abigailward@uchicago.edu). *Differential Harnack Estimates for Fisher's Equation.*

In this talk we derive two differential Harnack estimates for positive solutions of the second order partial differential equation $f_t = \Delta f + cf(1 - f)$, known as Fisher's Equation. This equation is useful as a fundamental model for reaction-diffusion equations across many fields.

If we let (M^n, g) be an n -dimensional compact Riemannian manifold with non-negative Ricci curvature and $f : M \times [0, \infty) \rightarrow \mathbb{R}$ be a positive solution to Fisher's Equation, then we derive a Harnack inequality of the form $\Delta(\log f) + \alpha|\nabla(\log f)|^2 + \beta f + \phi(t) \geq 0$, with an explicit $\phi(t)$ and bounds on α and β . By loosening the restrictions on M to complete but non-compact, we then derive a second inequality of the same general form but with a more intricate function $\phi(t)$. (Received September 25, 2012)

1086-35-2888 **Yan Wang***, David Rittenhouse Lab (DRL), 33rd Walnut Street, Philadelphia, PA 19104. *Decomposition of diffusion operators and application in image analysis.* Preliminary report.

Diffusion equation is a class of partial differential equation widely used in image analysis community, especially for multiscale analysis. The decomposition of diffusion operator using local coordinate system is considered as a better way to understand how the diffusion operators affect 1D or 2D signals, however there are contradicting conclusions of the decomposition form in the literature. In this talk, we would like to review the previous studies on diffusion operator decomposition and give a new formation and interpretation of the decomposition with both analytic analysis and numerical experiments for both 1D and 2D signals. As one application, the nonlinear diffusion operator will be shown for the detection of local image scale with any given orientation. (Received September 26, 2012)

1086-35-2891 **Lizheng Tao*** (ltao@math.okstate.edu), 401 MSCS O.S.U., stillwater, OK 74078. *Logarithmically Super-Critical Case in Boussinesq Equations and its Generalization.*

This talk will focus on the global regularity problem concerning some generalized Boussinesq systems in the supercritical cases. These include a logarithmically supercritical type in either the velocity form and in the dissipation term. The regularity is achieved by introducing a variation of the Besov space norm. We will show the conservation, which is global in time, of the L^q norm of both the vorticity and θ . The uniqueness of the solutions to these system is given at the end section. (Received September 26, 2012)

- 1086-35-2916 **V. B. Surya Prasath*** (prasaths@missouri.edu), Department of Computer Science, University of Missouri-Columbia, Columbia, MO 65211, and **Jose Alberto Iglesias Martinez** and **Dmitry Vorotnikov**. *On Generalized Perona–Malik Diffusion Equations in Image Processing*.

The Perona–Malik diffusion (PMD) widely used in various image processing tasks [Perona, P., Malik, J.: Scale-space and edge detection using anisotropic diffusion. IEEE Trans. Pattern Anal. Mach. Intell. 12(7), 629–639 (1990)] is an ill-posed [Kichenassamy, S.: The Perona-Malik paradox. SIAM J. Appl. Math. 57(5), 1328–1342 (1997)] nonlinear parabolic equation of the form

$$\frac{\partial u}{\partial t} = \operatorname{div} (g(|\nabla u|) \nabla u) \text{ with } u(0) = u_0$$

where $g : [0, \infty) \rightarrow [0, \infty)$ is the diffusion function, e.g., $g(s) = (1 + (s/K)^2)$ with $K > 0$ a parameter and u_0 is the noisy input image. We study a related PDE of the form

$$\frac{\partial u}{\partial t} = \operatorname{div} \left(\frac{\phi'(|\nabla u|) \nabla u}{1 + K |G_\sigma \star \nabla u|^2} \right)$$

where $\phi : \mathbb{R} \rightarrow [0, \infty)$ is an even and convex function. We study the above model and provide detailed analysis of the scheme. The purpose of this talk is to highlight important new results in this regard, and update the status of some of the related problems of such generalized PMD equations, and add some new problems to the list of open and unsolved problems in this area. (Received September 26, 2012)

37 ► Dynamical systems and ergodic theory

- 1086-37-5 **Laura De Marco*** (demarco@math.uic.edu). *Combining complex and arithmetic dynamics: a study of critically-finite maps*.

Questions about complex dynamical systems have traditionally been answered with techniques from analysis (complex or geometric). In the last 5 or 10 years, methods from arithmetic and algebraic geometry have begun to play a central role – and the result is an active new research area, the “arithmetic of dynamical systems” (to borrow the title of Silverman’s textbook on the subject). The questions themselves have evolved, inspired by results from arithmetic geometry. In this talk, I will present new joint work with Matt Baker, where we study “special points” within the moduli space of complex polynomial dynamical systems. (Received September 25, 2012)

- 1086-37-30 **Duokui Yan*** (duokuiyan@gmail.com), Beihang University, Haidian District, Xueyuan Rd #37, Beijing, 100191, Peoples Rep of China, and **Tiancheng Ouyang** and **Xiaojun Chang**. *Index and Linear Stability of the Criss-Cross Orbit*.

Maslov-type index iteration theory are applied to study the linear stability of the criss-cross orbit in the planar three-body problem. This orbit was first found by Broucke and Hénon, and later rediscovered and named by Moore. The symmetry group of this orbit is shown to be D_4 . Following Hu and Sun’s recent work, we show that this orbit is linearly stable. Surprisingly, the variational structure of this orbit guarantees its linear stability. (Received June 01, 2012)

- 1086-37-54 **Yiming Long*** (longym@nankai.edu.cn), Chern Institute of Mathematics, Nankai University, Tianjin, 300071, Peoples Rep of China. *Stability of elliptic Lagrangian solutions of the classical three body problem via index theory*. Preliminary report.

Lagrange found his famous equilateral triangle solutions of the classical planar three body problem in 1772 which depend on the mass parameter and eccentricity of the ellipse. The linear stability of such solutions has been investigated by perturbation methods or numerical methods. But we are not aware of any rigorous analytical method which works for this problem in the full range of parameters. In this lecture, I shall give an introduction on the new rigorous analytical method and recent results jointly obtained by Xijun Hu, Shanzhong Sun and myself on this linear stability problem for the full range of the masses and eccentricity via index theories for symplectic matrix paths. (Received June 21, 2012)

- 1086-37-140 **Ryan Mulcahy*** (mulcahy@augsborg.edu), Department of Mathematics, Augsburg College, Minneapolis, MN 55454, and **Christiana Sabett** (cmsabett@smcm.edu), Mathematics and Computer Science, St. Mary’s College of Maryland, St. Mary’s City, MD 20686. *Lang-Kobayashi*.

A system of two identical, delay coupled semiconductor lasers described by the Lang-Kobayashi equations is considered. We investigate the geometric background of the existence of compound laser mode (CLM) solutions, periodic solutions corresponding to a constant electric field amplitude and constant inversion number. Included

is an investigation of the bifurcation scenarios depending upon the coupling rate. The structure of stable CLM solutions is characterized on the coupling rate - detuning parameter domain. Time integration reveals an eventual loss of stability characterized by the appearance of pulsating solutions that develop into Low Frequency Fluctuations (LFFs). We identify individual regions for each type of solution on a limited portion of the coupling rate - detuning parameter plane. The structure of the regions on a larger subset of the plane is hypothesized based on regression analysis. (Received July 27, 2012)

1086-37-228 **John C Mayer*** (jcmayer@uab.edu), Department of Mathematics - UAB, CH 452, Birmingham, AL 35294-1170. *The Central Strip Lemma for Laminations of Degree > 2 .* Preliminary report.

Quadratic laminations of the unit disk were introduced by Thurston as a vehicle for understanding the (connected) Julia sets of quadratic polynomials and the parameter space of quadratic polynomials. The “Central Strip Lemma” plays a key role in Thurston’s classification of gaps in quadratic laminations, and in describing the corresponding parameter space. We generalize the notion of *Central Strip* to laminations of degree $d > 2$ and prove a Central Strip Lemma for degree $d > 2$. We conclude with an application of the Central Strip Lemma to cubic laminations, in particular to *identity return triangles*, that shows it may play a role similar to Thurston’s Central Strip Lemma in understanding higher degree laminations. (Received August 08, 2012)

1086-37-244 **Kelly Brooke Yancey*** (kbyancey1@gmail.com). *Rigidity in Topological Dynamics.* Preliminary report.

In 1989 Glasner and Maon introduced the idea of uniform rigidity as a topological analogue of classical rigidity in ergodic theory. This seems to be the correct topological analogue as similar generic properties hold in both settings. A homeomorphism T of a compact metric space X is said to be uniformly rigid if there exists an increasing sequence of natural numbers (n_m) such that T^{n_m} converges to the identity uniformly on X . We will use category arguments to construct large families of weakly mixing homeomorphisms of the two-torus and Klein bottle that are uniformly rigid. Then we will use these category arguments to give results toward characterizing their uniform rigidity sequences. (Received August 12, 2012)

1086-37-245 **Kelly Brooke Yancey*** (kbyancey1@gmail.com). *Uniformly Rigid Homeomorphisms.* Preliminary report.

A homeomorphism T of a compact metric space X is said to be uniformly rigid if there exists an increasing sequence of natural numbers (n_m) such that T^{n_m} converges to the identity uniformly on X . We will discuss the construction of a large family of weakly mixing homeomorphisms of the two-torus and the Klein bottle that are uniformly rigid. We will also discuss the structure of these uniform rigidity sequences. Specifically we will show that if a sequence of natural numbers satisfies a certain growth rate, then we can construct a weakly mixing homeomorphism of the two-torus that is uniformly rigid with respect to that sequence. (Received August 12, 2012)

1086-37-391 **Hexi Ye*** (hye4@uic.edu), 851 S Morgan Street, Room 322, Chicago, IL 60607. *Rational Functions with Identical Measure of Maximal Entropy.*

We discuss when two rational functions f and g can have the same measure of maximal entropy. The polynomial case was completed by (Beardon, Levin, Baker-Eremenko, ..., 1980s-90s), and we address the rational case following Levin-Prytycki (1997). We show: for generic f of degree $d \geq 3$, if $\mu_f = \mu_g$, then f and g share an iterate ($f^n = g^m$ for some n and m), under further generic condition, $\mu_f = \mu_g$ implies that $g = f^n$ for some $n \geq 1$. For generic $f \in \text{Rat}_2$, $\mu_f = \mu_g$ implies that for some $n \geq 1$, $g = f^n$ or $\sigma_f \circ f^n$, where σ_f permutes two points in each fiber of f . And we construct examples of f and g with $\mu_f = \mu_g$ such that $f^n \neq \sigma \circ g^m$ for any $\sigma \in \text{PSL}(2, \mathbb{C})$ and $m, n \geq 1$. (Received August 28, 2012)

1086-37-443 **Sukanya Basu*** (basu1s@cmich.edu), Department of Mathematics, Central Michigan University, Mt. Pleasant, MI 48859. *A Comparison of the Local and Global Dynamics of Monotone and Antimonotone Maps in the Plane.*

Monotone and antimonotone maps have widespread applications in many areas of real life. For example, monotone maps are associated to discrete competitive mathematical models in Biomathematics such as the Leslie-Gower population model. Antimonotone maps are associated to discrete mathematical models involving negative feedback loops such as mechanical control systems and gene regulatory networks. Although planar monotone maps are very well-understood at this point due to the works of Hirsch, Smith, Dancer and Hess, Kulenović and Merino etc., the same is not necessarily true for planar antimonotone maps. In this talk, I will discuss the local and global dynamics of orbits of a class of planar antimonotone maps. I will also compare this to the local

and global dynamics of orbits of a similar class of planar monotone maps to get some very interesting results. (Received September 02, 2012)

1086-37-509 **Nicholas Long*** (longne@sfasu.edu), PO Box 13040, SFA Station, Nacogdoches, TX 75965. *On Maps Commuting with the Flip Map.*

We present examples of automorphisms of the 2-shift which also commute with the flip map. Additionally, the subgroup of flip commuting automorphisms is studied with several homomorphisms from and to the automorphism group of the 2-shift. (Received September 05, 2012)

1086-37-546 **Dashiell E. A. Fryer*** (dashiell.fryer@pomona.edu) and **Marc Harper** (marcharer@ucla.edu). *Time-scale Lyapunov functions for Incentive Dynamics on Riemannian Geometries.*

Time-scale calculus allows the study of difference and differential equations simultaneously. In this talk we present the application of time-scale Lyapunov stability theory to game-theoretically inspired incentive dynamics on the simplex for a wide class of Riemannian geometries, giving time-scale Lyapunov functions in terms of information divergences for a large class of discrete and continuous-time dynamics that include many well-known dynamical systems in evolutionary game theory. These results include discrete time extensions of the adaptive dynamics of Hofbauer and Sigmund. We also discuss the relationship between incentive stability and evolutionary stability through a series of illustrative examples. (Received September 06, 2012)

1086-37-600 **Scott R. Kaschner***, 1138 Canterbury Square South, Indianapolis, IN 46260, and **Roland K. W. Roeder**. *Superstable Manifolds of Invariant Circles and Co-dimension 1 Böttcher Functions.*

Let $f : X \dashrightarrow X$ be a dominant meromorphic self-map, where X is a compact connected Hermitian manifold of dimension $n > 1$. Suppose there is an embedded copy of \mathbb{P}^1 that is invariant under f , with f holomorphic and transversally superattracting with degree a in some neighborhood. Suppose also that f restricted to this line is given by $z \rightarrow z^b$, with resulting invariant circle S . The regularity of the local stable manifold $\mathcal{W}_{\text{loc}}^s(S)$ is dependent on a and b . Specifically, I will show that when $a \geq b$, $\mathcal{W}_{\text{loc}}^s(S)$ is real analytic, and the condition $a \geq b$ cannot be relaxed without adding additional hypotheses. (Received September 08, 2012)

1086-37-617 **Paul M Reschke*** (presch2@uic.edu), Univ. of Ill. - Chicago, 851 S Morgan, Chicago, IL 60607. *Salem Numbers and Complex Surface Automorphisms.*

We will discuss complex surface automorphisms with positive entropy, addressing in particular the question of what values of entropy can be achieved by such automorphisms. A fundamental result in this area is that any positive value of entropy is necessarily the logarithm of the entropy of a Salem number. However, a Salem number in general need not necessarily give the entropy of some automorphism. We will present a complete characterization of the entropies of automorphisms of two-dimensional complex tori, as well as recent progress in the characterization of entropies of automorphisms of abelian surfaces. We will also review results and open questions for automorphisms of rational surfaces and K3 surfaces. (Received September 09, 2012)

1086-37-720 **Elizabeth D Russell*** (elizabeth.russell@wne.edu), 1215 Wilbraham Road, Springfield, MA 01119. *Singular Perturbations in the Quadratic Family.*

In recent years, families of complex rational maps that result from perturbing well known quadratic maps such as $Q_0(z) = z^2$ and $Q_c(z) = z^n + c$, where c is the center of the corresponding Multibrot set, have been of interest. In this presentation, we consider maps of the form $P_c(z) = z^2 + c$, where c is the center of a hyperbolic component of the Mandelbrot set, that have been perturbed by the addition of a pole or multiple poles which affect the superattracting cycle of the unperturbed map. We will focus on the topological and dynamical characteristics of the resulting Julia sets. In particular, we will give conditions which guarantee that the corresponding Julia set contains homeomorphic copies of the unperturbed Julia set, Cantor sets of quasicircles, and Cantor sets of point components that accumulate on these curves. (Received September 11, 2012)

1086-37-737 **Serge Tabachnikov*** (tabachni@math.psu.edu). *Tire tracks geometry and bicycle kinematics.*

This talk concerns a simple model of bicycle motion: a bicycle is a segment of fixed length that can move so that the velocity of the rear end is always aligned with the segment. The rear wheel track and a choice of direction determine the front wheel track; changing the direction to the opposite, yields another front track. The two front tracks are related by the Backlund-Darboux transformation which defines a discrete time dynamical system on the space of curves. This system is completely integrable and closely related with a well studied completely

integrable continuous time dynamical system, the filament (or binormal, or smoke ring) equation. (Received September 11, 2012)

1086-37-752 **Filiz Dogru*** (dogruf@gvsu.edu), **Daniel Hast** and **Neil DeBoer**. *On 3-Periodic Orbits of Polygonal Outer Billiards in The Hyperbolic Plane*. Preliminary report.

Outer (Dual) billiards is a simple plane based dynamical system on a convex shape. The subject popularized in the 70's with the search of orbits escape to infinity. In time, some results developed in the Euclidean and the hyperbolic plane. In this talk, we examine small polygonal outer billiard tables have 3-periodic orbits in the hyperbolic plane. We formulate a stronger smallness condition for polygonal tables — which we call triangle-small — and analyze possibilities of 3-periodic orbits. We prove several special cases: polygons with at least three acute or right angles, regular polygons, and quadrilaterals. (Received September 12, 2012)

1086-37-796 **Rudy Lee Horne*** (rhorne@morehouse.edu), Morehouse College, Department of Mathematics, 830 Westview Drive S.W., Atlanta, GA 30314. *Stability and dynamics of solitary waves in AlGaAs waveguide arrays and BEC spinor lattices*.

In the early 20th century, S. Bose and A. Einstein predicted the existence of a state of matter composed of weakly interacting bosons (integer spin particles). Today, this is known as the Bose-Einstein condensate. The BEC was first experimentally realized in 1995 by E. Cornell and C. Wieman (U. of Colorado at Boulder) and W. Ketterle (MIT).

The focus of this work concerns understanding solitary waves in two different systems: AlGaAs waveguide arrays and in spinor BEC lattice systems. Both the AlGaAs waveguide array and the spinor BEC lattice can be described by two sets of coupled, partial differential equations. In the waveguide array system, we (i) derive solitary wave solutions for the model of interest and (ii) analyze the existence and stability of said solutions via an anti-continuum limit. For the BEC spinor model, we focus on a three-component dynamical lattice model with a mean field nonlinearity. In a similar manner to the waveguide array system, we look at (i) an anti-continuum limit for the model of interest and (ii) the existence and stability of the solitary wave solutions via a perturbative approach.

Keywords: solitary waves, AlGaAs waveguide arrays, discrete lattice, spinor, Bose-Einstein Condensate (Received September 12, 2012)

1086-37-845 **Tuyen Trung Truong*** (tutruong@syr.edu), Department of Mathematics, Room 215 Carnegie Building, Syracuse University, Syracuse, NY 13244. *On automorphisms of blowups of P^3 or $P^2 \times P^1$* .

We will present a heuristic argument to show that it is difficult to find automorphisms $f : X \rightarrow X$ of positive entropies on compact Kahler manifolds X of dimension at least 3, and will discuss in detail the cases when X is a blowup of P^3 , or $P^2 \times P^1$, or $P^1 \times P^1 \times P^1$. (Received September 13, 2012)

1086-37-970 **Eugen Andrei Ghenciu*** (eghenciu@ecok.edu). *Renyi like Continued Fractions*. Preliminary report.

We study a class of continued fractions called Renyi like continued fractions and we investigate for which values of the parameter associated which each class we have full dimension spectrum. (Received September 17, 2012)

1086-37-1095 **Sarah Koch** and **Roland Roeder*** (rroeder@math.iupui.edu). *Postcritically finite rational mappings of $\overline{\mathcal{M}_{0,n}}$ arising from Thurston's Theorem*.

We study a family of maps $F_d : \mathcal{M}_{0,n} \dashrightarrow \mathcal{M}_{0,n}$ which arise as *moduli space maps* in the context of Thurston's topological characterization of rational maps. The space $\overline{\mathcal{M}_{0,n}}$ is the Deligne-Mumford compactification of the moduli space of n points on the Riemann sphere. It is isomorphic to an iterated blow-up of \mathbb{P}^{n-3} . The maps F_d are rational and postcritically finite; each one has a nonempty indeterminacy set. Each map F_d is constructed from a simple combinatorial procedure coming from Thurston's theorem. Using this, we can readily analyze the dynamical behavior; in particular, algebraic stability, dynamical degrees, and maximal invariant cohomology class, etc. (Received September 18, 2012)

- 1086-37-1191 **Tiancheng Ouyang** (ouyang@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602, **Zhifu Xie*** (zxie@vsu.edu), Department of Mathematics and Computer Science, P.O.Box 9068, Petersburg, VA 23806, and **Duokui Yan** (duokuiyan@gmail.com), School of Mathematics and System Science, Beihang University, Beijing, Peoples Rep of China. *Linear Stability of the periodic solution in the spatial isosceles three-body problem.*

We show that the equal-mass spatial isosceles three-body periodic solutions (one body is oscillating on the symmetrical axis and other two bodies are rotating each other) are unstable in the full three-body problem but some of them are linearly stable in the symmetrical subsystem of the three-body problem. After a nice decomposition of the full space $\mathbb{R}^{12} = \Sigma \oplus \Gamma$, the problem of linear stability in the full three body problem becomes two separated linear stability problems in two orthogonal subspaces Σ and Γ . In the symmetrical subspace Γ , by applying Roberts' symmetry reduction, we show that the periodic solutions are linearly stable in some cases. However, in the subspace Σ , all the periodic solutions are linearly unstable. (Received September 19, 2012)

- 1086-37-1226 **Linda Keen*** (lkeen@gc.cuny.edu), Mathematics Program CUNY Graduate Center, 365 Fifth Ave, New York, NY 10016, **Tao Chen** (chentaofdh@gmail.com), Mathematics Program CUNY Graduate Center, 365 Fifth Ave, New York, NY 10016, and **Yunping Jiang** (yunping.jiang@qc.cuny.edu), Mathematics Program CUNY Graduate Center, 365 Fifth Ave, New York, NY 10016. *Bounded Geometry and Characterization of post-singularly Finite (p,q)-Exponential Maps.*

In this talk, based on joint work with Yunping Jiang and Tao Chen, we define a topological class of branched covering maps of the plane called *topological exponential maps of type (p,q)* and denoted by $\mathcal{TE}_{p,q}$. We prove that an element $f \in \mathcal{TE}_{p,q}$ with finite post-singular set is combinatorially equivalent to an entire map of the form Pe^Q , where P is a polynomial of degree p and Q is a polynomial of degree q if and only if f satisfies a *bounded geometry* condition. (Received September 20, 2012)

- 1086-37-1262 **Alexander Wittig*** (wittigal@msu.edu), Biomedical and Physical Sciences Bldg, 567 Wilson Rd., East Lansing, MI 48823, and **Martin Berz**. *Analysis of Dynamical Systems in Accelerator Physics using Verified Computation.*

In the design and analysis of particle accelerators, dynamical systems emerge in a natural way. In Beam Physics accelerators are described by a special Poincaré section called the transfer map. This map is a non-linear symplectic map exhibiting chaotic motion in certain regions of phase space.

One of the goals of accelerator design is to identify and avoid such regions. Of particular interest is the estimation of the so called region of stability of a given system. Typically this task is performed by repetitive particle tracking to obtain tracking pictures.

In this talk we describe a method to compute rigorous enclosures of all fixed or periodic points of a given order in a map using Taylor Model methods. We then apply this algorithm to a real world transfer map of the Tevatron accelerator to rigorously identify resonances.

This mathematically rigorous method yields all regions where resonances up to a certain order appear. The island structure exhibited by the map around the identified periodic points is then studied further by computing the invariant manifolds associated with the hyperbolic periodic points of the map. The manifold structure around the periodic points provides further insight into the dynamics of the map, including the emergence of chaotic motion. (Received September 20, 2012)

- 1086-37-1325 **Akram Aldroubi*** (akram.aldroubi@gmail.com), 1520 Stevenson Center, Dept Mathematics, Vanerbilt University, Nashville, TN 37240, and **Jacqueline Davis** and **Ilya Krishtal**. *Dynamical Sampling: Exact reconstruction From sensing Networks.*

Let $V \subset L^2$ be a shift invariant subspace and $f \in V$ be an initial distribution that is evolving in time under the action of a family of (spatially) invariant evolution operators $\{A_t\}_{t \in [0, \infty)}$:

$$f_t(x) = (A_t f)(x). \quad (1)$$

Let X_m be the set $m\mathbb{Z}$, $m \in \mathbb{N}$. We study the conditions under which $f = f_0$ can be recovered from the samples $\{f(X_m), (A_1 f)(X_m), \dots, (A_T f)(X_m)\} \cup \{f(\Omega)\}$ in a stable way, where $\Omega \subset \mathbb{Z}$ is a small extra sampling sets judiciously chosen. (Received September 21, 2012)

- 1086-37-1427 **May Mei*** (mmei@math.uci.edu), Department of Mathematics, University of California, Irvine, Irvine, CA 92697-3875. *Discrete Schrödinger Operators with Primitive Invertible Substitution Potential*.

The Nobel Prize-winning discovery of quasicrystals has spurred much work in aperiodic sequences and tilings. Here, we consider one-dimensional discrete Schrödinger operators with potentials given by primitive invertible substitutions on two letters, which are a one-dimensional model of quasicrystals. Using tools from hyperbolic dynamics to study the trace map of these operators, we are able to show that as the coupling constant tends to zero, the thickness of the spectrum tends to infinity and thus the Hausdorff dimension of the spectrum tends to one. We also show that when the coupling constant is small, all gaps allowed by the gap labeling theorem are open, and further, open linearly. (Received September 23, 2012)

- 1086-37-1438 **Bethany Diane Springer*** (springer@math.colostate.edu), 2824 Dundee Court, Fort Collins, CO 80525. *Continued Exploration of Nearly Continuous Even Kakutani Equivalence*. Preliminary report.

Nearly Continuous Dynamics blends together measurable dynamics and topological dynamics by asking that properties nearly hold, i.e. hold when restricted to sets both topologically large and measure theoretically large. Two ergodic near homeomorphisms T and S of compact metric spaces X and Y are said to be nearly continuously evenly Kakutani equivalent (nceKe) if there exists a measure preserving, nearly continuous homeomorphism $\phi : X \rightarrow Y$ mapping orbits bijectively to orbits and a nearly clopen set A of positive measure such that ϕ restricts to a n.c. conjugacy between induced systems T_A and $S_{\phi(A)}$. While it is known that nceKe is a stronger relation than even Kakutani equivalence, examples or systems which fail to be nceKe have thus far been contrived. Using Loosely Bernoulli systems as a test bed, M. Roychowdhury and D. Rudolph showed that any two odometers are nceKe, and A. Dykstra and D. Rudolph added irrational rotations of a circle to this class. While working with A. del Junco, we expanded this class to include any system built from a cutting and stacking of the unit interval as well as all minimal isometries of compact metric spaces. (Received September 21, 2012)

- 1086-37-1526 **Joshua P Bowman*** (joshua.bowman@gmail.com). *Dynamics of Chebyshev-type maps on \mathbb{P}^k* .

I will describe some of the analytic and algebraic properties of the Chebyshev-type endomorphisms introduced in the 1980s by Veselov and Hoffman-Withers. (Received September 23, 2012)

- 1086-37-1612 **Tushar Das***, Dept of Mathematics, Oregon State Uni, 354 Kidder Hall, Corvallis, OR 97331. *Geometry and dynamics in hyperbolic spaces*.

We survey our recent work exploring infinite-dimensional models of hyperbolic space and related dynamics of analogues of discrete groups. We emphasize differences between our work and the well-developed theory generalizing the study of Kleinian groups in finite dimensions to proper Gromov hyperbolic metric spaces. Certain phenomena induced by the greater degrees of freedom in infinite dimensions (e.g. the abundant lack of properness and the variety of “discrete” actions one may consider) forces some delicacy. Highlights will include a classification theorem for groups of isometries acting on arbitrary Gromov hyperbolic metric spaces, a generalization of the Bishop-Jones formula equating the Poincaré exponent to the Hausdorff dimensions of the uniformly-radial and radial/conical limit sets respectively, and an extension of Patterson-Sullivan theory for groups of divergence-type. This project is joint work with David Simmons (Ohio State) and Mariusz Urbański (North Texas). (Received September 23, 2012)

- 1086-37-1774 **Ibrahim Oumar Diakite***, 411 S. Nedderman drive, Arlington, TX 76013, and **Benito Chen Charpentier**. *Numerical Methods for Delay Differential Equations with Application to Biology*. Preliminary report.

we present a numerical method for delay differential equations with application to some biology problems. Two different applications are presented. The first one is R.V Culshaw and S. Ruan DDE model of cell-free viral spread of human immunodeficiency virus (HIV) in a well-mixed compartment such as the bloodstream. A discrete time delay was introduced to describe take into account the time between infection of a CD4+ T-cell and the emission of viral particles at the cellular level. We present an analytic stability analysis of the endemically infected equilibrium. we then present a numerical analysis of the stability and bifurcation process of the same equilibrium using numerical tools. The second application is the DDE model proposed by Barlett and Wangersky. Their model is a Non-Kolmogorov-Type predator prey model with two discrete times delay. We again present an analytic and a numerical analysis of the stability and bifurcation process of the steady state solutions. Numerical simulations are presented to illustrate the results. (Received September 24, 2012)

- 1086-37-1921 **Suzanne Boyd*** (sboyd@uwm.edu), University of Wisconsin Milwaukee, Department of Mathematical Sciences, PO Box 413, Milwaukee, WI 53201. *Baby Julia sets and combinatorial models*. Preliminary report.

We will examine the dynamics of some maps from each of the following two families, including computing some Iterated Monodromy Group representations. Family (1) consists of ‘Singularly perturbed rational maps’, which are rational maps of the Riemann sphere of the form $R(z) = z^n + c + a/z^n$. Family (2) is ‘Polynomial skew products of \mathbb{C}^2 ’, which are endomorphisms of the form $F(z, w) = (p(z), q(z, w))$, where p and q are both monic of degree $d \geq 2$.

We will see how certain classes of maps from each family have dynamics which incorporates the dynamics of two hyperbolic quadratic polynomials (thus we’ll see baby Julia sets), and in the case of the rational maps of family (1), display the intriguing effects of this in parameter space. (Received September 24, 2012)

- 1086-37-1931 **Nicholas A Allgaier*** (nicholas.allgaier@uvm.edu), **Kameron D Harris** and **Christopher M Danforth**. *Empirical correction of a toy climate model*.

Improving the accuracy of forecast models for physical systems such as the atmosphere is a crucial ongoing effort. The primary focus of recent research has been reducing error in state estimation, but as that error has been successfully diminished, the role of model error in forecast uncertainty has duly increased. In this talk we investigate an empirical model correction procedure involving the comparison of short forecasts with a reference truth system, in order to calculate (1) state-independent model bias and (2) state-dependent error patterns. An estimate of the likelihood of the latter error component is computed from the current state at every timestep of model integration. The effectiveness of this technique is explored in a realistic scenario, in which the model is structurally different (in dynamics, dimension, and parametrization) from the target system. Results suggest that the correction procedure is more effective for reducing error and prolonging forecast usefulness than parameter tuning. However, the cost of this increase in average forecast accuracy is the creation of substantial qualitative differences between the dynamics of the corrected model and the true system. A method to mitigate dynamical ramifications and further increase forecast accuracy is presented. (Received September 24, 2012)

- 1086-37-1967 **Liang Kong*** (lzk0002@auburn.edu), 221 parker Hall, Auburn, AL 36849, and **Wenxian Shen**. *Positive Stationary Solutions and Spreading Speeds of KPP Equations in Locally Spatially Inhomogeneous Media*.

This paper mainly explores spatial spread and front propagation dynamics of KPP evolution equations with random or nonlocal or discrete dispersal in unbounded inhomogeneous and random media and reveals such an important biological scenario: the localized spatial in-homogeneity of the media does not prevent the population to persist and to spread, moreover, it neither slows down nor speeds up the spatial spread of the population. (Received September 24, 2012)

- 1086-37-1984 **Rachel Louise Bayless*** (rbayless@unc.edu), UNC - Chapel Hill Dept. of Mathematics, Phillips Hall CB #3250, Chapel Hill, NC 27599. *Entropy of Infinite Measure-Preserving Transformations*. Preliminary report.

The entropy of a system measures the amount of information gained with each application of an experiment or transformation, so higher entropy corresponds to higher disorder and less predictable systems. The classical definition of entropy for a measure-preserving system relies heavily on the ability to associate probabilities to possible events or outcomes. Thus, classical measure-theoretic entropy is only defined for probability-preserving transformations, and there is no universal analogue for infinite systems. A few possible extensions have been given independently by Krengel, Parry, and Roy.

In this talk we motivate the definition of Krengel entropy for infinite measure-preserving systems. We also provide a method for computing the Krengel entropy of all rational R -functions of negative type (rational functions which permute the upper and lower half planes of \mathbb{C} while preserving Lebesgue measure on \mathbb{R}). The Krengel entropy coincides with that of Parry and Roy in these cases. (Received September 24, 2012)

- 1086-37-2006 **David J Cosper*** (dcosper314@gmail.com), Dept. of Mathematics - UAB, Birmingham, AL 35294-1170. *Identity Return Triangles For Cubic Laminations*. Preliminary report.

A lamination \mathcal{L} is a closed collection of chords of the closed unit disk $\overline{\mathbb{D}}$ which do not intersect except at vertices. Laminations are used to study Julia sets abstractly. We are interested in invariant laminations under the map $\sigma_d(t) = dt \pmod{1}$ where $t \in [0, 1)$. A gap in a lamination \mathcal{L} is the closure of a component of $\overline{\mathbb{D}} \setminus \cup \mathcal{L}$. A finite gap is called a *polygon*. An *identity return polygon* (IRP) is a polygon which maps away from itself, while also preserving circular order, and eventually maps back to itself by the identity, and whose images are pairwise

disjoint. Kiwi proved that the number of sides of an IRP cannot exceed the degree d of the map σ_d . Some open questions about σ_d are

- (1) What is the minimum period of an IRP?
- (2) Do all periods above the minimum occur?
- (3) Given 3 points of a given period p , what are the criteria for forming an identity return triangle?
- (4) Given a period p , how many IRPs may be formed?

We show that for any d , no identity return d -gon of period $p = 2$ can exist under σ_d , though period $p = 2$ triangles may exist for all $d > 3$. (Received September 24, 2012)

1086-37-2025 **Danilo R. Diedrichs*** (danilo.diedrichs@wheaton.edu), Wheaton College, Department of Mathematics, 501 College Ave., Wheaton, IL 60187. *Reverse Engineering of the Unfolded Protein Response Network using Polynomial Dynamical Systems.*

The Unfolded Protein Response (UPR) is a regulatory mechanism in cell biology that has senses perturbations in the protein-folding capacity of the endoplasmic reticulum and takes corrective steps to restore homeostasis. A mathematical model of the UPR in mammalian cells was recently developed based on extensive prior knowledge of the architecture of the UPR network with parameters calibrated by time course experimental data. In this study, we propose to reverse-engineer the mammalian UPR network using only the data, without making any assumptions on the structure of the network. We use computational algebra techniques to determine a class of models given by polynomial dynamical systems over \mathbb{Z}_p consistent with the data. The resulting optimal network provides valuable insights on structural elements of the original model that may not have been considered during the classical forward engineering approach. (Received September 24, 2012)

1086-37-2181 **Irving Dai*** (ifdai@college.harvard.edu), 64 Linnaean St., 237 Currier Mail Center, Cambridge, MA 02138, **Xavier Garcia** (garci363@umn.edu), Minneapolis, MN 55455-0213, **Tudor Padurariu** (tudor_pad@yahoo.com), 540 Kelton Ave., Apt. 204, Los Angeles, CA 90024, and **Cesar E Silva** (csilva@williams.edu), Department of Mathematics and Statistics, 18 Hoxsey Street, Williamstown, MA 01267. *On Rationally Ergodic and Rationally Weakly Mixing Rank-One Transformations.*

We study the notions of weak rational ergodicity and rational weak mixing as defined by Jon Aaronson for infinite measure-preserving transformations. We partially characterize the families of rank-one transformations which possess (or do not possess) these properties, based on the construction of the transformations. We also consider the relation between rational weak mixing and other notions of mixing in infinite measure; to this end, we prove rational weak mixing implies double ergodicity and is independent of zero-type. (Received September 25, 2012)

1086-37-2195 **Xander Faber*** (xander@math.hawaii.edu) and **Laura DeMarco** (demarco@math.uic.edu). *Non-Archimedean Dynamics and Degenerations of Complex Dynamical Systems.* Preliminary report.

The measure of maximal entropy for a complex rational function varies continuously as one moves around in the parameter space of functions of fixed degree d . What happens as one approaches the boundary of this parameter space? By transferring this question to the Berkovich projective line, we answer it under a natural stability hypothesis. Our technique also gives a Markov process interpretation of equidistribution of pre-images for the limit measure, which allows one to explicitly determine the measure in many cases. (Received September 25, 2012)

1086-37-2282 **Joanna M. Furno*** (furno@live.unc.edu). *Haar Measures of p -adic Julia Sets.* Preliminary report.

For a fixed prime p , the set of p -adic numbers \mathbb{Q}_p is contained in an algebraically closed field \mathbb{C}_p . For some polynomial maps on \mathbb{C}_p , the Julia set of the polynomial is contained in \mathbb{Q}_p . This talk will discuss various possibilities for the Haar measure of such a Julia set. (Received September 25, 2012)

1086-37-2354 **A. Bonifant*** (bonifant@math.uri.edu), Mathematics Department, University of Rhode Island, Kingston, RI 02881, **X. Buff** (xavier.buff@math.univ-toulouse.fr), U.F.R.-M.I.G, Laboratoire Emile Picard, 31062 Toulouse, France, and **J. W. Milnor** (jack@math.sunysb.edu), Stony Brook University, Stony Brook, NY. *Antipode Preserving Cubic Rational Maps and Herman rings.* Preliminary report.

In this talk I will discuss a family of cubic rational maps which carry antipodal points of the Riemann sphere to antipodal points, with emphasis on the abundance of Herman rings. (Received September 25, 2012)

1086-37-2427 **Russell Waller*** (rwaller@math.fsu.edu). *Pseudo-Anosov flows on graph manifolds with periodic pieces*. Preliminary report.

In their recent work (arXiv:1007.0578v2), T. Barbot and S. Fenley demonstrate that the structure of pseudo-Anosov flows on Seifert pieces of graph manifolds where all pieces of the torus decomposition are periodic is actually quite rigid, and can be fully described using surfaces called *fat graphs*. We characterize these fat graphs with the extra restrictions needed to guarantee that the flows on the corresponding 3-manifolds are pseudo-Anosov, and in doing so provide many explicit new examples of pseudo-Anosov flows on graph manifolds where all pieces of the torus decomposition are periodic. (Received September 25, 2012)

1086-37-2460 **Michelle Manes*** (mmanes@math.hawaii.edu), Department of Mathematics, 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822, and **Bianca Thompson**. *Periodic Points in Towers of Finite Fields*. Preliminary report.

When iterating a polynomial function ϕ over a finite field, the orbit of any point $\alpha \in \mathbb{F}_{p^n}$ is a finite set; i.e. all points are pre-periodic. But many natural questions about the structure of orbits over finite fields remain:

- (1) Fix a finite field \mathbb{F}_{p^n} and look over all polynomials of fixed degree d : On average are there “lots” of periodic points with relatively small tails leading into the cycles? Or do we expect few periodic points with long tails?
- (2) Fix a polynomial: How does the proportion of periodic points in \mathbb{F}_p vary as $p \rightarrow \infty$?
- (3) Again fix a polynomial: How does the proportion of periodic points in \mathbb{F}_{p^n} vary as $n \rightarrow \infty$?

Recent work by Flynn and Garton addresses the first question. In her thesis, Madhu tackles the second question in the case $\phi(z) = z^m + c$.

We focus on the third question in the special case that the polynomial map $\phi(z)$ can be viewed as an endomorphism of an underlying algebraic group. The work is ongoing, and we hope to extend results if possible to more general polynomial maps. (Received September 25, 2012)

1086-37-2592 **Ana Vivas-Barber*** (avbarber@adams.edu), 180 Curtis Lane, Alamosa, CO 81101, and **Sunmi Lee** (mathever@gmail.com). *A mathematical Model for the Spread of the West Nile Virus in Colorado*. Preliminary report.

West Nile Virus (WNV) is a mosquito-borne disease: birds are the natural reservoir and the most common hosts are humans and horses; It was detected for the first time in the US in 1999 in New York City (CDC, 1999). Since then the spread of the virus has been tremendously increased among all the states (CDC, 2001) resulting in numerous human infectious and deaths. In 2012, there has been a considerable increase in infectious cases in Colorado (CDC, August 2012). The purpose of the present work is to develop a mathematical model for the transmission dynamics of the West Nile Virus (WNV) in Colorado. A system of nonlinear ordinary differential equations is formulated by incorporating the vital dynamics of vectors (mosquitos) as a function of temperature in order to capture the effect of the Global warming on a significant increase in the vector population. We find the equilibrium points of the model and the stability of the equilibrium points for a certain threshold quantity (R_0). This will help us understand the WNV transmission dynamics so that we can propose a better control strategy for the mosquito’s population and preventive strategies for the human and horse’s population. (Received September 25, 2012)

1086-37-2609 **Tanya Firsova*** (tanya@math.sunysb.edu), 5D-148, Math Tower, Stony Brook University, Stony Brook, NY 11794. *λ -lemma in \mathbb{C}^2 and its application to dynamics*.

We prove an analog of λ -lemma for families of Riemann surfaces with boundaries in \mathbb{C}^2 . We show that under natural conditions holomorphic motion from the boundary can be extended to a holomorphic motion of Riemann surfaces.

We apply our version of λ -lemma to prove the following result: for Hénon maps which are small perturbations of quadratic polynomials with disconnected Julia set, the critical loci are quasiconformally equivalent. (Received September 25, 2012)

1086-37-2649 **Tim Chumley**, Washington University in St. Louis, **Scott Cook*** (scook3@swarthmore.edu), Swarthmore College, and **Renato Feres**, Washington University in St. Louis. *From Billiard Dynamics to Thermodynamics*.

We develop a stochastic approach to thermodynamics using a randomized version of billiard dynamical systems. Our simple and explicit model gives a natural notion of temperature which, in turn, allows heat flow. Thus, we can construct machines from billiard dynamics. In this talk, we will build a simple heat engine and study characteristics like efficiency. (Received September 25, 2012)

- 1086-37-2651 **Maila Capuno Brucal Hallare*** (brucalhallare@tncc.edu), Thomas Nelson
Community College, 99 Thomas Nelson Dr, Hampton, VA 23666. *Antidiffusion lattice differential equations with quadratic nonlinearity.*

We consider a system of lattice differential equations with quadratic nonlinearity, but with a negative discrete diffusion coefficient. We are interested in the existence, uniqueness, stability, and nonexistence of the traveling wavefront solutions of this system. By rewriting this system as a spatially periodic system with inhomogeneous but positive periodic diffusion coefficients and periodic nonlinearities, we uncover a rich solution behavior that includes many possible connecting orbits in the antidiffusion case. (This paper applies the computational framework set forth in a paper published by the author in SIAM J of Applied Dynamical Systems; the title of the paper is Traveling Wavefronts in an Antidiffusion Lattice Nagumo Model.) (Received September 25, 2012)

- 1086-37-2652 **Kiran Parkhe*** (kparkhe@math.northwestern.edu), Math Department, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208. *Continuous actions of the discrete Heisenberg group on surfaces.*

The (discrete) Heisenberg group is the group $H = \langle a, b, c: aba^{-1}b^{-1} = c, ac = ca, bc = cb \rangle$. A continuous (smooth) action of H on a manifold M is a homomorphism $\Phi: H \rightarrow \text{Homeo}(M)$ ($\text{Diff}(M)$); in other words, it is a choice of homeomorphisms (diffeomorphisms) f, g , and h satisfying the Heisenberg group relations.

We study continuous/smooth actions of H on surfaces S . We give a C^∞ gluing procedure to produce many smooth examples. We show, however, that under certain hypotheses the situation becomes rigid. Namely, suppose $S = \mathbb{R}^2$ is the plane and h is conjugate to a translation. Suppose there exists a non-central element $k \in H$ and an h -invariant line ℓ such that $k(\ell)$ is disjoint from ℓ . Then there exists a non-central $k' \in H$ such that k' and h are “transverse translations”: $\mathbb{R}^2/\langle k', h \rangle$ is homeomorphic to the torus. Classifying such actions essentially reduces to classifying torus homeomorphisms. (Received September 25, 2012)

- 1086-37-2669 **Xiang-Sheng Wang*** (xswang@mun.ca), Dept of Math & Stat, Memorial University of Newfoundland, St. John's, NL A1C 5S7, Canada. *Dynamic threshold of patch disease model for migratory birds.* Preliminary report.

We study spread of avian influenza in migratory birds by a patch disease model which is a periodic delay system combining a cooperative sub-system and a predator-prey (SIR) sub-system. There are two kinds of basic reproductive ratio: one (R_0^c) for the birds to survive in the competition of birth and natural death; the other (R_0^p) for the disease to transmit from infected birds to susceptible birds. It can be shown that if the ecological R_0^c is less than one, then the bird population will decrease to zero; if the ecological R_0^c is greater than one and the epidemiological R_0^p is less than one, then the birds will survive and the disease will be cleared. However, if both ecological R_0^c and epidemiological R_0^p are greater than one, the birds and the disease will seek for a balance to reach an endemic periodic equilibrium or vanish eventually. It is thus suggesting that there exists a third R_0^e to determine the stability of trivial equilibrium for the coupled system. Here we derive an asymptotic formula for this third R_0^e by the method of finite dimensional reduction and asymptotic techniques. (Received September 25, 2012)

- 1086-37-2696 **Mickael D. Chekroun*** (mchekroun@atmos.ucla.edu), 405 Hilgard Ave/7127 Math Sciences Bldg, Los Angeles, CA 90095, and **David Neelin, Dmitri Kondrashov, James McWilliams** and **Michael Ghil**. *Rough parameter dependence in geophysical fluid models: The role of Ruelle resonances.* Preliminary report.

Based on the spectral theory of chaotic and dissipative dynamical systems, we argue that the time variability of recurrent large-scale patterns — typically simulated by geophysical fluid models — plays a potentially key role in the sensitive parameter dependence of long-term statistics of such models. The cornerstone of our approach consists of interpreting this variability in terms of Ruelle-Pollicott (RP)-resonances which encode crucial information about the nonlinear dynamics of the model. A new approach for estimating RP resonances — as filtered through observables of the system — will be also presented. This approach relies on appropriate representations of the dynamics by Markov operators which are adapted to a given observable. It will be shown — on an El Nino-Southern Oscillation (ENSO) model of intermediate complexity — that the model statistics are the most sensitive for the smallest spectral gaps of the associated Markov operator; such small gaps turn out to correspond to regimes where peaks in the power spectrum are the most energetic, while correlations decay more slowly. Theoretical arguments will be provided to discuss the possible generalizations of this work to more realistic climate simulations obtained with general circulation models (GCMs). (Received September 25, 2012)

1086-37-2777 **Alexander Blokh, Lex Oversteegen, Ross Ptacek*** (rptacek@uab.edu) and **Vladlen Timorin**. *Laminations from the Cuboid*. Preliminary report.

Thurston originally developed invariant laminations as a combinatorial model for Julia sets of quadratic polynomials and used them to construct a combinatorial model for the Mandelbrot set, the parameter space of quadratic polynomials. The *Principle Hyperbolic Domain* of degree d , PHD_d , is the set of degree d polynomials of degree d with a simple closed curve Julia set. $\text{Bd}(\text{PHD}_2)$, the *main cardioid*, is of fundamental importance to the structure of the Mandelbrot set and is homeomorphic to its combinatorial counterpart. In this talk we review the connection between laminations and Julia sets and describe the laminations that comprise $\text{Bd}(\text{PHD}_3)$, the *main cuboid*. (Received September 25, 2012)

1086-37-2851 **Esther R Widiasih*** (ewidiasih@math.arizona.edu), 617 N Santa Rita, Mathematics, University of Arizona, Tucson, AZ 85719. *A dynamics approach of snowball events*. Preliminary report.

The controversial Snowball events are believed to occur sometimes earlier than 650 Mya during the Neoproterozoic era. On one hand, energy balance models eg. by Budyko and Seller, assert that if ice cover extends to lower latitudes, then ice albedo runaway feedback happens, and Earth will be eternally covered by ice. On the other hand, based on geologic, geochemical and paleomagnetic evidences, geoscientists eg. Kirschvink, Hoffman and Schrag conclude that ice sheets have extended to the equatorial regions with snowball termination due to the CO_2 accumulation. It is no wonder that how a snowball happened and terminated is still a current and lively debate.

In this talk, I will explore a dynamical system based on Budyko's energy balance model, that is consistent with Kirschvink's theory of the snowball onset and termination. The system is obtained by adding dynamics to ice line as well as the greenhouse gas parameter closely related to the atmospheric CO_2 level in the Budyko's model, thereby treating them as state variables. The vector field governing this system is piecewise continuous at the boundary, with interesting dynamics in the interior (Received September 25, 2012)

1086-37-2853 **Evangelie Zachos*** (ezachos@princeton.edu), **Tudor Padurariu** (tudor_pad@yahoo.com) and **Cesar Silva** (cesar.e.silva@williams.edu). *Positive Type Infinite Measure Ergodic Transformations*.

In 1964, Hajian and Kakutani defined an infinite measure-preserving transformation T to be of zero type if $\lim_{n \rightarrow \infty} \mu(T^{-n}(A) \cap A) = 0$ for all A of finite measure, and they also observed that when T is conservative ergodic, if it is not of zero type then $\limsup_{n \rightarrow \infty} \mu(T^{-n}(A) \cap A) > 0$ for all A of finite positive measure. For a vector $v = (v_1, v_2, \dots, v_d)$ of positive entries we define T if v -positive type if $\limsup_{n \rightarrow \infty} \mu(A \cap T^{v_1 n}(A)) \dots \mu(A \cap T^{v_d n}(A)) > 0$.

We study this property and construct examples of rank-one and Markov shift transformations satisfying it. (Received September 25, 2012)

1086-37-2954 **Rodrigo A Perez***, LD-224R, 402 N. Blackford St., Indianapolis, IN 46202, and **Magnus Aspenberg**. *Catalan, Fibonacci, and Siegel*. Preliminary report.

An analytic function $f: \mathbb{C} \rightarrow \mathbb{C}$ has a Siegel disk at 0 if $f(0) = 0$, $f'(0) = e^{2\pi i \theta}$ ($\theta \notin \mathbb{Q}$), and there is an analytic map φ that conjugates f to its linear part $z \mapsto e^{2\pi i \theta} z$.

Most modern proofs of the existence of Siegel disks use quite sophisticated techniques. In contrast, Siegel's original proof was completely elementary, and has been largely forgotten. In this talk I will argue that going back to his 1942 methods, describing in detail the underlying combinatorics, has the potential to obtain sharper results than currently known. In particular, we will discuss lower bounds on the size of Siegel disks, and a famous conjecture of Carleson. (Received September 26, 2012)

1086-37-2982 **Eugenia Kalnay*** (ekalnay@atmos.umd.edu). *New Ensemble Kalman Filter Applications*. The Ensemble Kalman Filter (EnKF) has become increasingly the method of choice for data assimilation (DA). In particular the Local Ensemble Transform Kalman Filter (LETKF) is easily implemented and offers powerful uses of DA: 1) Improving models: EnKF allows estimation of optimal evolving model parameters without observations. It is possible to estimate and correct model biases and state dependent model errors during model integration. 2) Extracting more information from observations: Conventional EnKF can be suboptimal. More information from observations is possible by repeated use through Running in Place (RIP), with major forecast improvements. 3) Forecast sensitivity to observations: Kalnay et al. (2012) updated the formulation of "forecast sensitivity to observations without adjoint" of Liu & Kalnay (2008). Ota et al. (2012) applied it to real observations assimilation at NCEP, finding regional cases of forecast skill breakdown in the 24hr forecast, and identifying problematic observations. 4) Effective DA of rain: Current methods successfully assimilate

observed precipitation. Without DA however, the free forecasts worsen in a few hours. Lien et al (2012) found that assimilating a Gaussian transformed variable instead of rain within LETKF resulted in improved forecasts. (Received September 26, 2012)

39 ► *Difference and functional equations*

1086-39-395 **Zhivko S. Athanassov*** (zhivko@math.bas.bg), Institute of Mathematics, Bulgarian Academy of Sciences, G. Bonchev Str. 8, 1113 Sofia, Bulgaria. *Recurrent Solutions to Systems of Difference Equations*. Preliminary report.

In this talk, we consider the existence and the properties of Birkhoff-recurrent solutions of nonlinear systems of nonautonomous difference equations. We employ results of the classical theory of discrete dynamical systems. (Received August 29, 2012)

1086-39-510 **Lih-Ing W Roeger*** (lih-ing.roeger@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *NSFD schemes on two-dimensional Lotka-Volterra competition model and SIS and SIR epidemic models*. Preliminary report.

We construct discrete-time or difference equation systems of competitive Lotka-Volterra model, *SIS* model, and *SIR* epidemic model by applying the nonstandard finite difference (NSFD) schemes. A simple criterion is used to preserve positivity of solutions in all models. In some models, we present an exact finite difference scheme as well. The difference equation systems via NSFD schemes preserve almost all properties including the positivity of solutions, the conservation law, and the local and some of the global stability of the equilibria; therefore, the difference equations are said to be dynamically consistent with the analog continuous-time models. (Received September 05, 2012)

1086-39-521 **Justin Wright*** (jwright3@ncsu.edu). *Periodic Dynamical Systems of Population Models and Enveloping Functions*. Preliminary report.

The study of periodically forced systems of nonlinear difference equations has been of particular interest since Cushing and Henson conjectured the existence of a global attractor for a periodically forced Beverton-Holt model. Since then a tremendous amount of work has been done to provide structure to the theory of periodically forced difference equations, including conditions that guarantee global attractors for periodic dynamical systems. In this presentation I will provide conditions that guarantee the existence of global attractors for period n dynamical systems of population models using P. Cull's concept of enveloping functions. (Received September 05, 2012)

1086-39-584 **Erik S. Van Vleck**, 1460 Jayhawk Blvd, 405 Snow, Lawrence, KS 66045, and **Aijun Zhang*** (zhangai@ku.edu), 1460 Jayhawk Blvd, 405 Snow, Lawrence, KS 66045. *Competing Interactions and Traveling Wave Solutions in Lattice Differential Equations*.

The existence of traveling front solutions to bistable lattice differential equations in the absence of a comparison principle is studied. The results are in the spirit of those in Bates, Chen, and Chmaj for TRAVELING WAVES OF BISTABLE DYNAMICS ON A LATTICE, but are applicable to vector equations and to more general limiting systems. An abstract result on the persistence of traveling wave solutions is obtained and is then applied to lattice differential equations with repelling first and/or second neighbor interactions. (Received September 07, 2012)

1086-39-599 **Allan C. Peterson*** (apeterson1@math.unl.edu), Allan Peterson, Math Department, 237 Avery, Lincoln, 685880130. *Discrete Fractional Calculus*.

We will consider discrete delta fractional and nabla fractional calculus. Many properties will be presented along with variation of constants formulas. If there is time Green's functions will be discussed. (Received September 08, 2012)

1086-39-634 **Chris D. Lynd*** (chris@math.uri.edu), RI. *Using Difference Equations to Generalize Results for Periodic Nested Radicals*.

We investigate sequences of nested radicals where the indices, the coefficients, and the radicands are periodic sequences of real numbers. We show that one can determine the end behavior of a periodic nested radical by analyzing the basin of attraction of each equilibrium point, and each period-2 point, of the corresponding difference equation. Using this method of analysis, we prove a few theorems about the end behavior of nested radicals of this form. These theorems extend previous results on this topic because they apply to large classes of nested radicals that contain arbitrary indices, negative radicands, and periodic parameters with arbitrary periods. In addition, we demonstrate how to construct a periodic nested radical, of a general form, that converges to a

predetermined limit; and we demonstrate how to construct a nested radical that converges asymptotically to a periodic sequence. (Received September 10, 2012)

1086-39-675 **Vlajko L. Kocic***, Mathematic Department, Xavier University of Louisiana, 1 Drexel Dr., New Orleans, LA 70125. *On Global Asymptotic Behavior of Some Classes of Nonlinear Nonautonomous Difference Equations.*

We study the global asymptotic behavior of some classes of nonlinear nonautonomous difference equations with and without delay. In particular, the questions of boundedness, existence of unbounded solutions, oscillations, and extreme stability are addressed. For periodic systems we also study the existence and stability of periodic solutions, attenuation and resonance of periodic cycles. Examples include some well-known nonautonomous population models (Received September 10, 2012)

1086-39-801 **Abba B. Gumel*** (gumelab@cc.umanitoba.ca), Winnipeg, Manitoba R3T 2N2, Canada. *Dynamically-consistent NSFD Schemes for Epidemic Models.*

This talk addresses the problem of designing robust numerical methods, constructed using Mickens' Non-standard finite-difference discretization, for solving nonlinear dynamical systems associated with the transmission dynamics of human diseases. The central objective is to ensure that the discrete-time models to be developed are dynamically-consistent with the corresponding continuous-time models being approximated. In particular, key qualitative properties of the continuous-time models (such as positivity, boundedness, bifurcations, asymptotic stability etc.) must be preserved. (Received September 12, 2012)

1086-39-803 **Toka Diagana*** (tokadiag@gmail.com), Department of Mathematics, Howard University, Washington, DC 20005, and **Martin Arienmughare.** *Existence Results for Some Singular Difference Equations.* Preliminary report.

This talk is concerned with the existence of almost periodic solutions to some classes of singular difference equations. Under some reasonable sufficient conditions, various existence results will be established. A few illustrative examples will also be discussed. (Received September 13, 2012)

1086-39-921 **Youssef N Raffoul*** (yraffoul1@udayton.edu), yraffoul1@udayton.edu, Dayton, OH 45469-2316. *Stability in Highly Nonlinear Delay Difference Systems.* Preliminary report.

We use fixed point theory and obtain stability results concerning the nonlinear functional difference system

$$\Delta x(n) = -a(n)g(x(n-r)) \quad (1)$$

with initial function $\psi : [-r, 0] \rightarrow \mathbb{R}$, where g is continuous, locally Lipschitz, and odd, while $x - g(x)$ is nondecreasing and $g(x)$ is increasing on an interval $[0, L]$.

(Received September 16, 2012)

1086-39-931 **H. Sedaghat*** (hsedagha@vcu.edu). *Solving linear difference equations in rings using reduction of order.*

Linear difference equations may be defined in rings that are not necessarily fields. In this context, one way of studying the solutions of the equation is through reduction of order, via semiconjugate factorization, into linear equations of lower orders. We show that a sufficient condition for this reduction to occur is the existence of a unitary solution for the homogeneous part of the equation. A unitary solution generates an eigensequence (eigenvalues are constant eigensequences) and the eigensequence generates a semiconjugate factorization. We use second-order difference equations whose coefficients may be variable or constant to illustrate and to apply various results. For instance, we show how to obtain new formulas for classical special functions that satisfy linear recurrences in a ring of real-valued functions (e.g., modified Bessel functions). (Received September 16, 2012)

1086-39-1009 **Sinan Kapcak*** (skapcak@trinity.edu), One Trinity Place, Department of Mathematics, Trinity University, San Antonio, TX 78212, and **Saber Elaydi** and **Unal Ufuktepe.** *Stability and invariant manifolds of a discrete host-parasitoid model.* Preliminary report.

We will investigate the stability and invariant manifolds of a discrete host-parasitoid model. The model is a generalized Beddington-Nicholson-Bailey model. (Received September 17, 2012)

- 1086-39-1025 **Candace M. Kent*** (cmkent@vcu.edu), Virginia Commonwealth University, Department of Mathematics and Applied Math., 1015 Floyd Avenue, P.O. Box 842014, Richmond, VA 23284-2014, and **Michael A. Radin**. *On the Boundedness Nature of Positive Solutions of the Difference Equation $x_{n+1} = \max \left\{ \frac{A_n}{x_{n-k}}, \frac{B_n}{x_{n-l}} \right\}$ with Variable Parameters.*

Preliminary report.

We investigate the boundedness nature of positive solutions of the difference equation

$$x_{n+1} = \max \left\{ \frac{A_n}{x_{n-k}}, \frac{B_n}{x_{n-l}} \right\}, \quad n = 0, 1, \dots,$$

where $\{A_n\}_{n=0}^{\infty}$ and $\{B_n\}_{n=0}^{\infty}$ are sequences of positive real numbers. We give sufficient conditions on A_n and B_n such that every solution is unbounded. (Received September 18, 2012)

- 1086-39-1107 **Ummugul Bulut*** (gul.bulut@ttu.edu), 8908 Dixon ave, Lubbock, TX 79423, and **Edward J. Allen** (edward.allen@ttu.edu), Texas Tech University, Department of Mathematics, Broadway and Boston, Lubbock, TX 79409. *Derivation of stochastic differential equations for macroevolutionary process.*

Deterministic and stochastic systems of ordinary differential equations are derived that describe the evolutionary dynamics of genera and species. Two different hypotheses are made in the model construction; the rate of change of the number of genera is either proportional to the number of genera in the family or is proportional to the number of species in the family. The first set of assumptions is the same as those used by Yule in his probabilistic study of macro evolutionary process. Asymptotic and exact numbers of species per genera are formulated for both models. Computational results for the derived systems of ODEs and SDEs agree well with the observed results for several families. Moreover, for each family, SDE models yield estimates of variability in the processes which are difficult to obtain using classical methods to study the dynamics of species and genera formation. (Received September 19, 2012)

- 1086-39-1437 **Yevgeniy Kostrov** and **Zachary Kudlak*** (zachary.kudlak@msmc.edu), Newburgh, NY 12550. *On the Boundedness Character of a System of Rational Difference Equations in the Plane with Nonnegative Periodic Coefficients.* Preliminary report.

In this preliminary report, we investigate the global stability, periodic character, and the boundedness nature of the solutions of several special cases which are contained in the system of difference equations

$$x_{n+1} = \frac{\alpha_n}{\beta_n x_n + y_n}, \quad y_{n+1} = \frac{a_n + b_n x_n + c_n y_n}{A_n + B_n x_n + C_n y_n}, \quad n \geq 0,$$

where initial conditions x_0 are y_0 are nonnegative and not both zero, and where the coefficients are nonnegative and periodic such that the denominators are always positive. (Received September 21, 2012)

- 1086-39-1569 **Jim M. Cushing*** (cushing@math.arizona.edu), Department of Mathematics, 617 N Santa Rita Av, University of Arizona, Tucson, AZ 85721, and **Simon Maccracken Stump**. *Difference equations arising in evolutionary population dynamics.*

Difference equation models in population dynamics that arise in the modeling of certain life history strategies, namely semelparity, give rise to an interesting dynamic dichotomy. This dichotomy consists of two invariant sets, each of which is a potential attractor: one is an equilibrium lying in the interior of the positive cone and the other lies on the boundary of the positive cone (and yields synchronized periodic orbits). Which of these is the attractor depends on the nature of the nonlinearities (specifically the strengths of the nonlinear interactions between and within age classes). I will describe the difference equations that arise when such a population is subject Darwinian evolution and give theorems that describe the nature of the dynamic dichotomy in an evolutionary context. Several open problems will arise, especially concerning the global stability of equilibria and cycles. (Received September 23, 2012)

- 1086-39-1652 **M Drymonis**, **Y Kostrov*** (ekostrov@yahoo.com) and **Z Kudlak**. *On Rational Difference Equations with Periodic Coefficients.*

We investigate the boundedness and convergence of solutions to the second order rational difference equations of the form

$$x_{n+1} = \frac{\alpha_n + \beta_n x_n x_{n-1} \gamma_n x_{n-1}}{A_n + B_n x_n x_{n-1} C_n x_{n-1}}$$

where the coefficients $\alpha_n, \beta_n, \gamma_n, A_n, B_n, C_n$ are nonnegative and periodic. (Received September 23, 2012)

- 1086-39-1665 **Chuan Zhang*** (zhang@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523-1874, and **Gerhard Dangelmayr** and **Iuliana Oprea**. *Learning Cycles in Hopfield-type Networks with Delayed Coupling*.

Cyclic patterns of neuronal activity are ubiquitous in neural systems of almost all animal species. To elucidate the underlying dynamical mechanisms for the storage and retrieval of cyclic patterns in neural networks is fundamentally important for understanding the origin of rhythmic movements. In this presentation, we summarize our investigations in the storage and retrieval of binary cyclic patterns in continuous, asymmetric Hopfield-type networks with delayed coupling using the pseudoinverse learning rule. The presentation is organized into three parts. First, we show that all cyclic patterns satisfying the transition conditions can be successfully stored and retrieved, and the cyclic patterns satisfying the same transition condition can be stored in the same network, and retrieved with appropriately selected initial conditions. Next, we show how the subspace structures of the vector space spanned by the row vectors of the cyclic patterns determine the topology of the networks constructed from these cyclic patterns. Last, we show that transitions from fixed points to attracting limit cycles (cyclic patterns) are multiple saddle-node bifurcations on limit cycles. (Received September 26, 2012)

- 1086-39-1814 **Ani P. Velo*** (avelo@sandiego.edu), Department of Mathematics & Computer Science, University of San Diego, 5998 Alcala Park, San Diego, CA 92110, and **George A. Gazonas** (george.a.gazonas.civ@mail.mil), US Army Research Laboratory, Weapons and Materials Research Directorate, Aberdeen Proving Grd, MD 21005. *Stress wave propagation in one-dimensional Goupillaud-type layered elastic media with applications to optimization, resonance and impact problems*.

We consider a one-dimensional layered Goupillaud-type elastic medium (equal wave travel time for each layer), subjected to a discrete forcing function or other impact conditions at one end and held fixed or free at the other end. A first-order system of difference equations describes the exact values of the stress terms in the discrete model. Further analysis of the system using z-transform methods provides insight to optimal designs that minimize the stress amplitude when the discrete forcing function is the Heaviside loading. When the discrete forcing function is sinusoidal and varies harmonically with time, the resonance frequency spectrum is described analytically. Finally, in selected impact problems, the stress and velocity limit values related to the (steady) long term behavior of the system are predicted analytically. A key aspect of this work is that it provides exact solutions and analytical results for verification of computational codes used to solve large scale problems. (Received September 24, 2012)

- 1086-39-1834 **Saber N Elaydi*** (selaydi@trinity.edu), One Trinity Place, San Antonio, TX 78212, and **Eduardo Balreira** and **Rafael Luis**. *Global Stability of a class of non-monotone competition models via singularity theory*. Preliminary report.

In this talk we will focus on the two-dimensional Ricker competition model. Our main objective is to show that, under certain conditions on the parameters, local stability of the interior fixed point implies global stability. The main tools of the investigation are Whitney's singularity theory and the theory of critical curves. The results are partial and much work is still needed to have a complete theory. (Received September 24, 2012)

- 1086-39-1857 **Mikheil Tutberidze*** (mikheil.tutberidze@iliauni.edu.ge), 3/5 Kakutsa Cholokashvili ave., 0162 Tbilisi, Rep of Georgia, **George Katsia** (gkatsia@delta.ge), 2 Gaprindauli str., 0154 Tbilisi, Rep of Georgia, and **Soso Pipia** (jpipia@delta.ge), 2 Gaprindauli str., 0154 Tbilisi, Rep of Georgia. *Numerical Solution and Convergence of the Difference Scheme for Initial-Boundary Value Problem to One Nonlinear Parabolic Equation*.

In the presented work the difference scheme for initial-boundary problem to the following nonlinear parabolic equation

$$\frac{\partial U}{\partial t} = a(x, t, U) \frac{\partial^2 U}{\partial x^2} + b(x, t, U) \left(\frac{\partial U}{\partial x} \right)^2 + f(x, t)$$

is constructed. The coefficients $a(x, t, U)$ and $b(x, t, U)$ are required to be continuous and to have continuous partial derivative with respect to argument U . Additionally coefficient $a(x, t, U)$ is required to be positive. The function $f(x, t)$ is required to be continuous. For the mentioned difference scheme the theorem of existence of its solution and the theorem of convergence of its solution to the solution of the source problem are proved. The rate of convergence is established and it is equal to $O(\tau + h^2)$. The corresponding numerical experiments are conducted which confirm the validity of the theorems. (Received September 24, 2012)

1086-39-1900 **Eddy A Kwessi*** (ekwessi@trinity.edu), One Trinity Place, San Antonio, TX 78212. *A Contest-Competition model with Allee Effect*. Preliminary report.

In this talk, we investigate the stability and bifurcation of a two-dimensional contest-competition model with Allee effect. We utilize the notion of critical curves and singularity theory to investigate the global dynamics of the system (Received September 24, 2012)

1086-39-1916 **N Josephy, M Predescu*** (mpredescu@bentley.edu) and **S Woolford**. *Analysis of a Nonlinear Difference Equation Model*.

We will present some results on the global stability character of solutions of a deterministic population model given by a nonlinear system of difference equations. In addition, a stochastic extension is proposed and discussed. (Received September 24, 2012)

1086-39-1961 **William T Jamieson*** (bill@math.uri.edu), 5 Lippitt Road, Department of Mathematics, Kingston, RI 02881, and **Orlando Merino** (merino@math.uri.edu), 5 Lippitt Road, Department of Mathematics, Kingston, RI 02881. *On the asymptotic behavior of convergent solutions to difference equations*.

The asymptotic behavior of convergent solutions to difference equations $x_{n+1} = T(x_n)$ for $n \geq 0$, where T is two times continuously differentiable map on an open subset of \mathbb{R}^n or \mathbb{C}^n is considered.

It can be shown from results by C. V. Coffman that if \bar{x} and J denote respectively the limit of a convergent solution $\{x_n\}$ and the jacobian of T at \bar{x} , then there exist $y \in \mathbb{R}^n$ or \mathbb{C}^n and a positive number ρ such that ρ is equal to the modulus of one the characteristic roots of J , $\|x_n\|^{1/n} = \rho + o(\rho^n)$, and $x_n = \bar{x} + J^n y + E_n$, where $E_n = o(n^k \rho^n)$.

We give sharp asymptotic estimates for E_n in the case when J is diagonalizable. (Received September 24, 2012)

1086-39-2209 **Guihong Fan*** (guihong.fan@asu.edu), School of Mathematical and Statistical Scienc, Arizona State University, P.O.Box 871804, Tempe, AZ AZ 85287-1. *Impact of temperature and bird species diversity on the transmission of West Nile virus*.

West Nile virus is a typical infectious disease which can cause severe illness in humans or animals. Vectors like mosquitoes play a critical rule in the transmission and spread of the diseases. We formulate a delay differential equation model for the transmission of West Nile virus between mosquitoes and avian hosts, which incorporates maturation delay for mosquitoes. Analytical analysis shows that vectors alone can force the system to oscillate under the impact of temperature. We also studied the impact of the bird species diversity. Our studies indicate that conservation of avian species diversity can help reduce human exposure to the virus. But on the contrary, bird species diversity also increases the chance for virus to survive and may be responsible for the repeated outbreak of the disease from year to year. (Received September 25, 2012)

1086-39-2881 **Christopher S. Goodrich*** (cgood@prep.creighton.edu), Creighton Preparatory School, 7400 Western Avenue, Omaha, NE 68114. *On a First-Order Semipositone Discrete Fractional Boundary Value Problem*.

In this presentation we discuss the existence of at least one positive solution to a discrete fractional semipositone boundary value problem. Since the boundary condition we consider is potentially both nonlinear and nonlocal, the problem we study is possibly very general. In addition, we shall especially focus on the construction of the Green's function for this problem. Finally, as part of this presentation we shall discuss some recent developments in the discrete fractional calculus and highlight the differences and similarities between the integer-order and fractional-order settings. (Received September 25, 2012)

40 ► Sequences, series, summability

1086-40-1363 **Xiao-Xiong Gan*** (xiao-xiong.gan@morgan.edu), Department of Mathematics, Morgan State University, Baltimore, MD 21251. *Formal Power Series and The Boundary Convergence of Power Series*.

The behavior of power series on boundary of convergence domain has been an interesting topic since power series was introduced. For example,

$$f(x) = \sum_{n=1}^{\infty} \frac{(-1)^n}{n} x^n$$

converges on $(-1, 1]$ but diverges at $x = -1$.

The composition of formal power series has been an important part of the *formal power series* theory. We introduce some new results about the boundary convergence of a (*regular*) power series by means of some new development in formal power series. (Received September 21, 2012)

1086-40-1515 **Lisa Lorentzen*** (lisa@math.ntnu.no). *Continued Fractions Converge with Probability One.*

Of course, this statement depends on the probability measure chosen. What we shall do is to regard a continued fraction $K(a_n/b_n)$ with complex entries a_n, b_n as a sequence $\{S_n\}$ of non-singular linear fractional transformations generated by compositions $S_n = s_1 \circ s_2 \circ \dots \circ s_n$ where $s_n(z) := a_n/(b_n + z)$. With proper conditions on a probability measure on the family of such transformations $s(z) = a/(b + z)$, we prove that $K(a_n/b_n)$ converges with probability one. A basic tool in this investigation is Furstenberg's celebrated theorem. (Received September 23, 2012)

41 ► Approximations and expansions

1086-41-177 **Maxim L. Yattselev*** (maximy@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *Bernstein-Szegő theorem on algebraic S -contours.*

Given function f holomorphic at infinity, the n -th diagonal Padé approximant to f , say $[n/n]_f$, is a rational function of type (n, n) that has the highest order of contact with f at infinity. Equivalently, $[n/n]_f$ is the n -th convergent of the continued fraction representing f at infinity. Bernstein-Szegő theorem provides an explicit non-asymptotic formula for $[n/n]_f$ and all n large enough in the case where f is the Cauchy integral of the reciprocal of a polynomial with respect to the arcsine distribution on $[-1, 1]$. In this work, Bernstein-Szegő theorem is extended to Cauchy integrals on the so-called *algebraic S -contours*. (Received August 03, 2012)

1086-41-751 **Willi Freeden*** (freeden@mathematik.uni-kl.de), Geomathematics Group, University of Kaiserslautern, 67663 Kaiserslautern, Germany. *From Fourier to Wavelets: A Geomathematical Course.*

A great deal of geomathematical work depends on methods for representing a georelevant phenomenon in terms of elementary, well-understood phenomena.

In this lecture we motivate the study of approximation techniques by indicating the circumstances in which a certain method may be useful and by describing some of the connections between areas of constructive approximation and various topics in geomathematics and -engineering. A central topic is the uncertainty principle. (Received September 12, 2012)

1086-41-770 **Mohammad A AlQudah*** (alqudahm@northwood.edu), 4000 Whiting Drive, Jordan A, Midland, MI 48640, and **James R Angelos**, PE 214, Mount Pleasant, MI 48859. *Characterization of Best Approximation in Generalized Haar Space of Tensor Product Type.*

Let X be a finite set with the discrete topology and $C(X, \mathbb{R}^k)$ be the space of vector valued continuous functions from X to k -dimensional Euclidean space \mathbb{R}^k ; and let G denote the space

$$G := \text{span}\{u^{j,d} | u^{j,d}(x) = u_{j,d}(x)e_d, j = 1, \dots, n_d, d = 1, \dots, k\} \subseteq C(X, \mathbb{R}^k)$$

with $u_{j,d} \in C(X, \mathbb{R})$, e_d , the standard basis vectors in \mathbb{R}^k , and let n_1, \dots, n_k be the dimensions of the component spaces comprising G , with $n_1 + \dots + n_k = n$.

This work is devoted to the study of best approximation of $f \in C(X, \mathbb{R}^k)$ from G in the uniform norm. In addition, we investigate the properties that characterize the best approximation. (Received September 12, 2012)

1086-41-2332 **Marc Kjerland*** (kjerland@math.uic.edu) and **Rafail Abramov**. *Linear response closure approximation for slow dynamics of a multiscale system with linear coupling.*

Many applications of contemporary science involve multiscale dynamics, typically characterized by time and space scale separation of patterns of motion with a large set of rapidly evolving variables and a smaller set of slowly evolving variables. This causes direct numerical simulation to be computationally expensive, due to the large number of variables and to the small timestep discretization needed for the fast-scale dynamics. We present a method to obtain a closed system for the evolution of the slow variables requiring only a simple computation of statistics of the fast variables and use of the fluctuation-dissipation theorem, a tool from statistical dynamics, to get a correction term for the averaged fast dynamics. We apply this method to a two-scale model with

linear coupling and accurately capture the statistics of the full system and response to forcing perturbations. (Received September 25, 2012)

1086-41-2630 **Bruce C Berndt, Sun Kim, M Tip E Phaovibul*** (phaovib1@illinois.edu) and **Alexandru Zaharescu**. *Diophantine Approximation with Partial sums of power series.*

Let $\{a_n\}_{n>0}$ be a sequence of real numbers, and $G(s) := \sum_{n=0}^{\infty} \frac{a_n}{n!} s^n$. For a nonzero rational number r , we consider the problem of approximating $G(r)$ with a partial sum of the series. In the case $a_n \equiv 1$ and $s = 1$, which gives $G(1) = e$, Sondow conjectured in 2008 that exactly two of these partial sums are also convergents to the continued fraction of e . These was proved by Berndt, S. Kim and Zaharescu in 2012. In this talk we will discuss some results and data regarding different sequences $\{a_n\}_{n>0}$. These included the case when $\{a_n\}$ are the real Dirichlet character, the coefficient of an L-series attached to an elliptic curve, or when a_n denotes the number of ways of writing n as a product of k integers. This is joint work with B. Berndt, S. Kim, and A. Zaharescu. (Received September 25, 2012)

1086-41-2634 **Tariq M Qazi***, Department of Mathematics and Comp. Sc., Petersburg, VA 23806. *L^p inequality for entire functions of exponential type.*

Let f be a polynomial of degree n . It is well known that $\int_{-\pi}^{\pi} |f'(e^{i\theta})|^p d\theta \leq n^p \int_{-\pi}^{\pi} |f(e^{i\theta})|^p d\theta$. Let g be an entire function of exponential type τ such that $g \in L^p(R)$ where $p > 0$. As an extension of the above inequality for entire functions of exponential type τ , it is also well known that $\int_{-\infty}^{\infty} |g'(x)|^p dx \leq \tau^p \int_{-\infty}^{\infty} |g(x)|^p dx$. A polynomial f of degree n is called a self-reciprocal if it satisfies the condition $f(z) = z^n f(1/z)$. Lately, many papers have been written on these polynomials. If f is a self-reciprocal polynomial, then $g(z) := f(e^{iz})$ is an entire function of exponential type n such that $g(z) = e^{inz} g(-z)$. Govil [N. K. Govil, L^p inequalities for entire functions of exponential type, Math. Inequal. Appl. 6 (2003) 445-452] studied the class of entire functions g of exponential type satisfying the condition $g(z) = e^{i\tau z} g(-z)$. We will discuss L^p inequalities for self-reciprocal polynomials and entire functions of exponential type discussed by Govil.

(Received September 25, 2012)

42 ► Fourier analysis

1086-42-93 **Nicholas Boros***, Olivet Nazarene University, Department of Mathematics, Bourbonnais, IL 60914. *Laminates Meet Burkholder Functions.*

Let R_1 and R_2 be the planar Riesz transforms. We compute the L^p -operator norm of a quadratic perturbation of $R_1^2 - R_2^2$ as

$$\|(R_1^2 - R_2^2, \tau \cdot Id)\|_{L^p(\mathbb{C}, \mathbb{C}) \rightarrow L^p(\mathbb{C}, \mathbb{C}^2)} = ((p^* - 1)^2 + \tau^2)^{\frac{1}{2}},$$

for $1 < p < 2$ and $\tau^2 \leq \frac{1}{2p-1}$ or $2 \leq p < \infty$ and $\tau \in \mathbb{R}$. To obtain the lower bound estimate of, what we are calling a quadratic perturbation of $R_1^2 - R_2^2$, we discuss a new approach of constructing laminates (a special type of probability measure on matrices) to approximate the Riesz transforms. Both the upper bound and lower bound estimates of the operator rely on using the results for the estimates on the quadratic perturbation of the martingale transform (a joint result with P. Janakiraman and A. Volberg). This is a joint result with L. Székelyhidi, Jr. and A. Volberg. (Received July 13, 2012)

1086-42-556 **Jill Pipher*** (jpipher@math.brown.edu), Department of mathematics, Brown University, Providence, RI 02906. *Neumann and regularity problems for second order elliptic operators with non-smooth coefficients.*

I will describe recent progress in Neumann and regularity boundary value problems for second order divergence form elliptic operators, when the coefficients satisfy certain natural, minimal smoothness condition. Specifically, we consider operators $L = \text{div}(A\nabla)$ such that $A(X) = (a_{ij}(X))$ is strongly elliptic in the sense that there exists a positive constant Λ such that

$$\Lambda |\xi|^2 \leq \sum_{i,j} a_{ij}(X) \xi_i \xi_j < \Lambda^{-1} |\xi|^2,$$

for all X and all $\xi \in \mathbb{R}^n$. We do not assume symmetry of the matrix A . There are a variety of reasons for studying the non-symmetric situation. These include the connections with non-divergence form equations, and the broader issue of obtaining estimates on elliptic measure in the absence of special L^2 identities which relate tangential and normal derivatives. The results described are joint work with M. Dindos and D. Rule for

operators satisfying a Carleson condition, and with S. Hofmann, C. Kenig and S. Mayboroda for operators with time-independent bounded measurable coefficients. (Received September 06, 2012)

1086-42-1056 **Armen Vagharshakyan*** (armen@math.brown.edu). *Lower bounds for L_1 discrepancy.*

We find the best constant of the leading term of the asymptotical lower bound for the L_1 norm of two-dimensional axis-parallel discrepancy that could be obtained by K.Roth's "test function" method among a large class of test functions. We use the methods of combinatorics, probability, complex and harmonic analysis. (Received September 18, 2012)

1086-42-1265 **John J. Benedetto*** (jjb@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20782. *Gabor frame and rotated DFT matrices for transform-based image compression.* Preliminary report.

A specific optimal Gabor frame is defined with the goal of optimal transform-based image compression with regard to sparsity as it affects speed of transmission and efficiency of storage. We also introduce the natural notion of $p \times p^2$ DFT matrices in terms of p rotations. We analyze compression in terms of the sparsity of OMP solutions of $Ax = b$, for A both optimal Gabor and rotated DFT. This is a collaboration with Robert Benedetto, Alfredo Nava-Tudela, and Joseph Woodworth. (Received September 20, 2012)

1086-42-1336 **Nasser Dastrange*** (dastrange@bvu.edu), 610, West Fourth Street, Storm Lake, IA 50588. *Walsh Fourier Analysis and Grey Codes.* Preliminary report.

It is well known that Walsh functions can be written as the product of Rademacher functions, which preserve the order of zero crossing.

In this talk we will generate Walsh functions by using binary and Grey codes. Walsh functions can be used in Fourier analysis to generate Walsh Fourier series and transforms.

Additionally, some interesting properties, examples, graphs, and recent research of the Walsh Fourier analysis will be presented. (Received September 21, 2012)

1086-42-1682 **Ahmed I Zayed***, Department of Mathematical Sciences, DePaul University, Chicago, IL 60614. *Sampling with the Prolate Spheroidal Wave Functions: A New Perspective.*

A sampling theorem for bandlimited functions using the prolate spheroidal wave functions as a basis has recently been obtained and shown to have some advantages over the classical Whittaker-Shannon-Kotel'nikov sampling theorem. In this talk we show that this new sampling theorem is a special case of a more general result in reproducing-kernel Hilbert spaces. (Received September 24, 2012)

1086-42-2416 **Jessica Christine De Silva*** (jdesilva1@csustan.edu). *Quantitative Analyses of Haar vs. Periodic Haar Wavelets.* Preliminary report.

In his paper *A Finite-Dimensional Approach to Wavelet Systems on the Circle*, Brody Johnson has developed the notion of finite-dimensional multiresolution analysis (MRA) wavelet systems on the circle S^1 . Johnson formulates an example of a wavelet with strong similarities to the traditional Haar wavelet. We compare and contrast the two related wavelets by developing quantitative analyses of a periodic sound file that has undergone wavelet transforms via the Haar wavelet and Johnson's Haar-like example. (Received September 25, 2012)

1086-42-2742 **Adam Martinez*** (aemarti6@asu.edu). *Edge Detection from Non-Uniform Fourier Data via an Adapted Method of Convolutional Gridding.*

The detection of edges from discrete Fourier data is a field of interest in a variety of image processing contexts from radio astronomy to medical imaging. For example, segmentation and target identification algorithms require knowledge of internal boundaries. The Fast Fourier Transform (FFT) is the industry standard for all image processing applications from Fourier data, including reconstruction and segmentation. However, it relies on the spectral data being sampled at integer points. In applications such as magnetic resonance imaging (MRI), it has recently become more common for this frequency data to be non-uniformly sampled because various new sampling schemes allow for better minimization of artifacts using the same number of sampling locations. The method of convolutional gridding (also referred to as the non-uniform FFT) is commonly practiced as a means to "regrid" non-uniform data to integer points for the purpose of image reconstruction. In this talk we deconstruct the convolutional gridding method and describe how its parameters can be analytically determined for better accuracy and efficiency in image processing applications such as reconstruction and segmentation. (Received September 25, 2012)

- 1086-42-2755 **Alexander Elkholy*** (aelkholy@asu.edu). *Integral approximations in reconstructing functions from non-uniform Fourier data.* Preliminary report.

The reconstruction of piecewise continuous functions from non-uniform Fourier data has several applications, notably in the field of medical imaging. We are particularly interested in examining several methods of function reconstruction in the context of vector space frames. Specifically, we survey the accuracy of composite trapezoidal/Simpson's rule quadrature methods to generate an inverse frame approximation, and compare these to a new method that relies on Gauss-Hermite quadrature. This talk will include a brief theoretical discussion and computational results, as well as a short description of its applications to magnetic resonance imaging. (Received September 25, 2012)

43 ► Abstract harmonic analysis

- 1086-43-439 **Yayuan Xiao*** (xiao@math.wayne.edu), Detroit, MI 48201. *Weighted multi-parameter Hardy spaces associated with Zygmund dilations.*

Among the multi-parameter analysis, the Zygmund dilations are the simplest after pure product space dilations. We established the weighted multi-parameter Hardy spaces $H_{\mathcal{Z}}^p(\omega)$ associated with Zygmund dilations for $0 < p < \infty$ and $\omega \in A_{\infty}(\mathcal{Z}) = \cup_{1 \leq p < \infty} A_p$, the weighted class associated with the Zygmund dilation. And we proved the $(H_{\mathcal{Z}}^p(\omega), H_{\mathcal{Z}}^p(\omega))$ ($0 < p < \infty$) boundedness and the $(H_{\mathcal{Z}}^p(\omega), L_{\mathcal{Z}}^p(\omega))$ ($0 < p \leq 1$) boundedness of the Ricci-Stein multi-parameter singular integral operators for $w \in A_{\infty}(\mathcal{Z})$. Moreover, we characterized the dual spaces of $H_{\mathcal{Z}}^p(\omega)$, that is, $(H_{\mathcal{Z}}^p(\omega))^* = CMO_{\mathcal{Z}}(\omega)$ for all $0 < p \leq 1$ and $\omega \in A_{\infty}(\mathcal{Z})$. Such Carleson measure spaces plays the same role as the John-Nirenberg BMO spaces in the duality $H^1(\mathbb{R}^n) - BMO(\mathbb{R}^n)$ in the non-weighted one-parameter setting when $p = 1$ and $\omega = 1$. Our argument is based on the discrete Calderón reproducing formula and Littlewood-Paley-Stein theory associated with the Zygmund dilations. (Received September 01, 2012)

- 1086-43-1453 **Malabika Pramanik*** (malabika@math.ubc.ca), 1984 Mathematics Road, Department of Mathematics, University of British Columbia, Vancouver, BC V5B 2E7, Canada, and **Rudra P Sarkar**. *Chaotic dynamics of the heat semigroup in Riemannian symmetric spaces.*

We show that the heat semigroup generated by certain perturbations of the Laplace-Beltrami operator on the Riemannian symmetric spaces of noncompact type is *chaotic* on their L^p -spaces when $2 < p < \infty$. Both the range of p and the range of chaos-inducing perturbation are sharp. This extends a result of Ji and Weber where it was shown that under identical conditions the heat operator is *subspace-chaotic* on these spaces. (Received September 22, 2012)

- 1086-43-1646 **Norbert N Youmbi*** (nyoumbi@francis.edu), 117 Evergreen Dr, Sullivan 114, Loretto, PA. *Weak Convergence on Topological Semihypergroups.*

We generalize some convergence results from semigroups to semihypergroups. In particular we use the definition of concretization of hypergroups (naturally extended to semihypergroups) to prove some results on weak convergence of the sequences or averages of convolution powers on topological semihypergroups. (Received September 23, 2012)

- 1086-43-1807 **wael abushammala*** (wabusham@gmail.com), University of Palestine, 00001 Gaza, Israel. *Periodic Decomposition of BMO.*

It is known that a bounded function can be represented as the sum of periodic function. In this talk we will discuss the periodic decomposition for functions with bounded mean oscillations. (Received September 24, 2012)

45 ► Integral equations

- 1086-45-1692 **Tadele Mengesha*** (mengesha@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802, and **Qiang Du**. *Mathematical Analysis of linear peridynamics.*

We analyze the linear bond-based peridynamic model of continuum mechanics. The focus is on models of isotropic elastic materials that allow an indefinite micromodulus kernel. Using standard variational techniques we prove the well posedness of the system of equilibrium equations, given as a nonlocal boundary value problem. We will also study the Cauchy problem of the time dependent equations of motion. In the event of vanishing

nonlocality solutions of the nonlocal system are shown to converge to the Navier system of classical elasticity. Our analysis is based on some nonlocal Poincaré-type inequalities and compactness of the corresponding nonlocal operators. (Received September 24, 2012)

1086-45-1944 **Javad Abdalkhani*** (abdalkhani.1@osu.edu), The Ohio State University -Lima, 4240 Campus Drive, Lima, OH 45804. *Using Mathematica to Find the Exact or to Approximate the Analytical Solution of Volterra Equations*. Preliminary report.

The literature of the Volterra equations lacks simple and user friendly programs for their solutions in symbolic languages. In this talk two Mathematica programs are offered to find either the exact or the approximate solution of the Volterra equations: A powerful theorem in the literature due to R. Kress states that for all linear Volterra equations the Picard successive iterations, is always convergent. For cases where Picard's iteration fails to converge we introduce a Mathematica program for an implicit mid-point rule. In both cases the Aitken accelerator is used to speed up the convergence. (Received September 25, 2012)

1086-45-2438 **Pablo Seleson***, ICES, The University of Texas at Austin, 201 East 24th St. Stop C0200, Austin, TX 78712, and **Max Gunzburger** and **Michael L Parks**. *Mathematical Modeling and Analysis of Interface Problems for Nonlocal Diffusion*.

This talk focuses on modeling and analysis of interface problems for systems characterized by nonlocal diffusion processes. Comparisons to classical local interface problems, involving partial differential equations, and extensions to coupled local/nonlocal systems will be presented. Numerical simulations demonstrating different features of these kinds of systems will be provided. (Received September 25, 2012)

1086-45-2506 **Jon Jacobsen*** (jacobsen@g.hmc.edu), **Mark Lewis** and **Yu Jin**. *Integrodifference Models for Persistence in Temporally Varying Habitats*. Preliminary report.

We consider integrodifference models of growth and dispersal on finite domains to investigate population dynamics in the context of local growth dynamics with temporally varying dispersal kernels. We consider several measures for persistence in the context of single, periodic, and random kernel parameters. (Received September 25, 2012)

46 ► Functional analysis

1086-46-34 **Mark Burgin***, Department of Mathematics, UCLA, Los Angeles, CA 90095. *Feynman Integral in the Context of Hyperintegration*. Preliminary report.

Hyperintegration essentially extends the class of integrable functions. In (Burgin, M. Hyperintegration Approach to the Feynman Integral, *Integration: Mathematical Theory and Applications*, v. 1, No. 1, 2008, pp. 59-104), the Feynman path integral is formalized in the context of hyperintegration. The advantage of this approach is that Feynman path hyperintegral always exists, taking, in general, values in the space of hypernumbers. When the value of the Feynman path hyperintegral is finite, it defines the corresponding Feynman path integral. Here we study properties of the Feynman path integrals and hyperintegrals. It is demonstrated that many properties of conventional integrals, such as linearity, positivity or continuity, are preserved for Feynman path integrals and hyperintegrals. These properties allow mathematicians, physicists and other researchers to operate with the Feynman path integrals and hyperintegrals in a mathematically grounded way. In particular, it provides means for Feynman path integral regularization. (Received June 05, 2012)

1086-46-454 **Ioana Ghenciu*** (ioana.ghenciu@uwrf.edu), 410 S. 3rd Street, River Falls, WI 54022. *The Dunford-Pettis Property of Tensor Product Spaces*.

We give sufficient conditions on Banach spaces E and F so that their projective tensor product $E \otimes_{\pi} F$, and the duals of their projective and injective tensor products do not have the Dunford-Pettis property. We prove that if E^* does not have the Schur property, F is infinite dimensional, and every operator $T : E^* \rightarrow F^{**}$ is completely continuous, then $(E \otimes_{\epsilon} F)^*$ does not have the DPP. We also prove that if E^* does not have the Schur property, F is infinite dimensional, and every operator $T : F^{**} \rightarrow E^*$ is completely continuous, then $(E \otimes_{\pi} F)^* \simeq L(E, F^*)$ does not have the DPP. (Received September 03, 2012)

- 1086-46-593 **Teffera M. Asfaw*** (tasfaw@mail.usf.edu), University of South Florida, Department of Mathematics and Statistics, 4202 E.Fowler ave., STOP CMC 342, Tampa, FL 33620-5700, and **Athanassios G. Kartsatos** (hermes@usf.edu). *Variational Inequalities for Perturbations of Maximal Monotone Operators in Reflexive Banach Spaces*. Preliminary report.

Let X be a real reflexive locally uniformly convex Banach space with locally uniformly convex dual space X^* , and let K be a nonempty, closed and convex subset of X with $0 \in \overset{\circ}{K}$. Let $T : X \supseteq D(T) \rightarrow 2^{X^*}$ be maximal monotone and $S : D(S) = K \rightarrow 2^{X^*}$ possibly unbounded pseudomonotone, or finitely continuous generalized pseudomonotone, or regular generalized pseudomonotone. Let $\phi : X \rightarrow (-\infty, \infty]$ be a proper, convex and lower semicontinuous function and fix $f^* \in X^*$. New results are given concerning the solvability of perturbed variational inequalities involving the operator $T + S$ associated with the function ϕ . The associated range results for nonlinear operators are also given, as well as extensions and/or improvements of known results of Kenmochi, Le, Browder, Browder and Hess, De Figueiredo, Zhou, and others. (Received September 07, 2012)

- 1086-46-607 **Michael Anshelevich*** (manshel@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Generators of the q -Brownian motion*.

The q -Brownian motion is a certain non-commutative random process whose distributions are the q -Gaussian distributions, and for which the Rogers q -Hermite polynomials are martingale polynomials. Bożejko, Kümmerer, and Speicher showed that it is a (non-stationary) Markov process, and computed its transition functions. In this talk, I will compute the generators of these transition functions. The proof involves q -stochastic calculus, but the question is a purely special functions question, and so it would be interesting to have a purely special functions proof. (Received September 08, 2012)

- 1086-46-639 **Hafedh Herichi and Michel L. Lapidus*** (lapidus@math.ucr.edu), University of California, Department of Mathematics, Riverside, CA 92521-0135. *The Spectral Operator and Its Applications: Quantized Riemann Zeta Function and Infinitesimal Shift of the Real Line*.

We discuss recent work of H. Herichi and the presenter where we provide a rigorous functional analytic definition of the spectral operator. Earlier, this operator was defined heuristically in a 2006 Springer monograph (2nd ed., 2012) by the presenter and M. van Frankenhuysen as the operator which sends the geometry onto the spectrum of a fractal string. Here, we precisely define it as acting on a suitable scale of Hilbert (or weighted Sobolev) spaces, indexed by the dimension c of the underlying fractal strings, and in terms of suitable boundary conditions. Via the measurable functional calculus for unbounded normal operators, it is equal to the composition of the Riemann zeta function $\zeta(s)$ and D , the underlying differentiation operator or ‘infinitesimal shift’. We plan to discuss several applications of the spectral operator: (1) To a spectral reformulation of the Riemann hypothesis (extending and interpreting from an operator theoretic point of view the corresponding reformulation obtained by the presenter and H. Maier in the 1990s). (2) To different types of ‘phase transitions’ (at $c = 1/2$ and $c = 1$) associated with the Riemann zeta function and its present quantizations. (3) To the study of ‘universality’ (and a new quantum analog) of ζ . (Received September 10, 2012)

- 1086-46-955 **Peter G Casazza*** (casazzap@missouri.edu), Department of Mathematics, Columbia, MO 65211. *Fusion Frames for Wireless Sensor Networks*.

We look at a series of recent papers which involve applications of fusion frames to wireless sensor networks for threat detection. (Received September 17, 2012)

- 1086-46-979 **Paul S. Muhly*** (paul-muhly@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242, and **Baruch Solel** (mabaruch@tx.technion.ac.il), Department of Mathematics, Technion, 32000 Haifa, Israel. *Hardy Algebras, Berezin Transforms, and Taylor’s Taylor Series*. Preliminary report.

Let $H^\infty(E)$ be the Hardy algebra of a countably generated W^* -correspondence E over a σ -finite W^* -algebra M . Let Σ be an additive subcategory of the category of normal representations of M on Hilbert space. For $\sigma \in \Sigma$, $D(0, 1, \sigma)$ is the open unit ball in the intertwiner space $I(\sigma^E \circ \varphi, \sigma)$, where σ^E is the representation induced by E in the sense of Rieffel and φ gives the left action of M on E . Each $F \in H^\infty(E)$ determines a natural, holomorphic, $B(H_\sigma)$ -valued function \widehat{F}_σ on $D(0, 1, \sigma)$ called the σ -Berezin transform of F . The family $\{\widehat{F}_\sigma\}_{\sigma \in \Sigma}$ is uniformly bounded by $\|F\|$ and satisfies the intertwining equation $C\widehat{F}_\sigma(z) = \widehat{F}_\tau(w)C$ for each C that intertwines σ and τ and satisfies $Cz = w(I_E \otimes C)$. Using Taylor’s Taylor series, we show how these intertwining relations enable one to recapture the Berezin transforms. (Received September 17, 2012)

1086-46-1099 **Kelly Bickel*** (kbickel@math.wustl.edu). *Inner Functions on the Bidisk and Associated Hilbert Spaces.*

It is well known that operator-valued inner functions on the bidisk admit decompositions in terms of pairs of reproducing kernels, called Agler Decompositions. In this talk, we will review known canonical decompositions and use them to characterize general Agler decompositions. We will discuss how certain properties of an inner function are reflected in the structure of the Hilbert function spaces associated to its Agler Decompositions. Particular attention will be paid to matrix-valued rational inner functions and the differences between the scalar and matrix-valued cases. This is joint work with Greg Knese. (Received September 25, 2012)

1086-46-1110 **Benoit Collins***, 585 King Edward, Ottawa, Ontario K1N6N5, Canada. *Norm convergence of unitary random matrix models and quantum information theory.*

I will speak about a generalization of a paper by Haagerup and Thorbjørnsen, where we obtain norm convergence of polynomials in independent unitary Haar distributed random matrices. I will explain how this result helps us to understand the typical behaviour of random quantum channels. This is a report on joint works with Serban Belinschi, Camille Male, Motohisa Fukuda, Ion Nechita. (Received September 19, 2012)

1086-46-1126 **Alexander A. Katz*** (katz@stjohns.edu), St. John's University, SJC of LAS, Dep. of Math & CS, 8000 Utopia Parkway, SJH 334-i, Queens, NY 11439. *On KSGNS-type theorem for representations in Hilbert O^* -modules.*

For A be a O^* -algebra of Sarymsakov and Goldstein, we introduce and study Hilbert A -modules. Among other things, a KSGNS-type theorem for Hilbert O^* -modules is proven. (Received September 19, 2012)

1086-46-1230 **Ken Dykema** (kdykema@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368, and **Francisco J Torres-Ayala*** (tfrederico.math@gmail.com), UNAM, Campus Juriquilla, Facultad de Ciencias, Boulevard Juriquilla 3001, 76230 Santiago de Queretaro, Mexico. *Primitivity and unital full free products of residually finite dimensional C^* -algebras.*

A C^* -algebra is called primitive if it admits a faithful and irreducible $*$ -representation. Using compact perturbations M.-D. Choi proved that $C^*(\mathbb{F}_n)$, the full group C^* -algebra of the free group of rank $n \geq 2$, is primitive. In joint work with Ken Dykema we prove that if A_1 and A_2 are unital, separable, residually finite dimensional C^* -algebras satisfying $(\dim(A_1) - 1)(\dim(A_2) - 1) \geq 2$, then $A_1 * A_2$, the unital full free product, is primitive. In this talk we present the main idea behind the proof and some consequences. (Received September 20, 2012)

1086-46-1360 **Waleed K. Al-Rawashdeh*** (walrawashdeh@mttech.edu), Department of Mathematical Sciences, Montana Tech, Butte, MT 59701. *Composition Operators between Weighted Bergman and S^p Spaces.*

Let φ be an analytic self-map of open unit disk \mathbb{D} . The operator given by $(C_\varphi f)(z) = f(\varphi(z))$, for $z \in \mathbb{D}$ and f analytic on \mathbb{D} is called composition operator. For each $p \geq 1$, let S^p be the space of analytic functions on \mathbb{D} whose derivatives belong to the Hardy space H^p . For $\alpha > -1$ and $p > 0$ the weighted Bergman space A_α^p consists of all analytic functions in $L^p(\mathbb{D}, dA_\alpha)$, where $dA_\alpha(z) = \frac{(1+\alpha)}{\pi} (1 - |z|^2)^\alpha dA(z)$ is the normalized weighted area measure.

In this talk, we characterize boundedness and compactness of composition operators act between weighted Bergman A_α^p and S^q spaces, $1 \leq p, q < \infty$. Moreover, we give a lower bound for the essential norm of composition operator from A_α^p into S^q spaces, $1 \leq p \leq q$. (Received September 21, 2012)

1086-46-1421 **Don Hadwin*** (don@unh.edu), Math Dept UNH, 33 Academic Way, Durham, NH 03824, and **Qihui Li, Weihua Li and Junhao Shen**. *Recent Results in Topological Free Entropy Dimension.* Preliminary report.

We discuss new and old results concerning Voiculescu's Topological Free Entropy Dimension, including an improved change of variables result. We also introduce a new related invariant that applies to all C^* -algebras and not just the class of MF C^* -algebras. (Received September 21, 2012)

1086-46-1469 **Todd Kemp*** (tkemp@math.ucsd.edu), 9500 Gilman Drive #0112, La Jolla, CA 92093-0112, and **Brian Hall** (bhall@nd.edu), 134 Hayes-Healy Hall, Notre Dame, IN 46556. *The Free Unitary Segal-Bargmann-Hall Transform.*

The Segal-Bargmann transform is unitary map from the L^2 space of Gaussian measure to the holomorphic L^2 space of (a dilated) Gaussian measure, that intertwines the Schrödinger and Heisenberg pictures in quantum mechanics. Hall later generalized it, in the context of geometric quantization, to compact Lie groups: the Segal-Bargmann-Hall transform maps the L^2 space of the heat kernel measure on the group G to the holomorphic L^2 space of the complexified group $G_{\mathbb{C}}$ with its (dilated) heat-kernel measure.

Taking $G = U(n, \mathbb{C})$ the $n \times n$ unitary group, and boosting the transform to be matrix valued, Biane studied the action on functional calculus, and developed a free Segal-Bargmann-Hall transform using free Malliavin calculus; however, his construction does not make direct contact with the finite-dimensional transform. Here, we will discuss an extension of this picture to a larger class of functions (dense in the equivariant functions on $U(n, \mathbb{C})$) that identifies Biane's transform as the limit as $n \rightarrow \infty$ of the Segal-Bargmann-Hall transform on $U(n, \mathbb{C})$. (Received September 22, 2012)

1086-46-1483 **William E Gryc*** (wgryc@muhlenberg.edu), Department of Mathematics & Computer Science, Muhlenberg College, 2400 Chew St, Allentown, PA 18104, and **Todd Kemp**. *Sharpness Results for Duality in Segal-Bargmann Spaces*. Preliminary report.

For $\alpha > 0$ let γ_α denote the standard Gaussian probability measure on \mathbb{C}^n with variance $(2\alpha)^{-n}$. Let $L_{hol}^p(\gamma_{\alpha p/2})$ denote the holomorphic functions that are contained in $L^p(\gamma_{\alpha p/2})$. Janson, Peetre, and Rochberg showed that $L_{hol}^p(\gamma_{\alpha p/2})$ and $L_{hol}^{p'}(\gamma_{\alpha p'/2})$ are dual to each other under the L^2 -pairing $(\cdot, \cdot)_\alpha$ of $L_{hol}^2(\gamma_\alpha)$. In previous work the authors found an inequality of the equivalence of the norms. Specifically,

$$\|g\|_{L^{p'}(\gamma_{\alpha p'/2})} \leq \|(\cdot, g)_\alpha\|_{(L_{hol}^p(\gamma_{\alpha p/2}))^*} \leq \left(\frac{2}{p^{1/p} p'^{1/p'}}\right)^n \|g\|_{L^{p'}(\gamma_{\alpha p'/2})}.$$

This talk will address in-progress research regarding the sharpness of the constants in the above inequality. In particular, we will demonstrate a direct relationship between the fiber over g of the projection $P_\alpha : L^p(\gamma_{\alpha p/2}) \rightarrow L_{hol}^p(\gamma_{\alpha p/2})$ and the dual norm $\|(\cdot, g)_\alpha\|_{(L_{hol}^p(\gamma_{\alpha p/2}))^*}$, a pointwise bound for functions in $L_{hol}^p(\gamma_{\alpha p/2})$, and sharpness in the first inequality given above. (Received September 22, 2012)

1086-46-1540 **Julian M Buck*** (jbuck@fmarion.edu), Department of Mathematics, PO Box 100547, Florence, SC 29506. *Smallness and Comparison Properties in Certain Topological Dynamical Systems*. Preliminary report.

We survey recent work (by N. Christopher Phillips, Taylor Hines, the author, and others) on certain types of regularity properties for topological dynamical systems, which have important applications to the classification theory of C^* -algebras. Concepts of smallness and comparison for closed sets, especially in the case of minimal dynamical systems, will be presented and compared, and these will be used to formulate regularity properties for the dynamical systems themselves. Explicit examples show these properties are weaker in general than finite covering dimension for the space. Several open questions will be presented. (Received September 23, 2012)

1086-46-1631 **Alexander A. Katz** (katza@stjohns.edu), St. John's University, SJC of LAS, 300 Howard Avenue, DaSilva Academic Center 314, Staten Island, NY 10301, and **Oleg Friedman*** (friedman001@yahoo.com), UNISA, RSA/, Lander College for Men-Touro College, 75-31 150th Street, Kew Gardens, NY 11367. *On Kadison Transitivity Theorem for real locally C^* -algebras*.

In the paper a version of Kadison Transitivity Theorem for real locally C^* -algebras is proven. (Received September 23, 2012)

1086-46-1637 **Sofya S Masharipova** (sofya.masharipova@ashford.edu), Ashford University, College HHSS, 400 North Bluff Blvd, Clinton, IA 52732, and **Shukhrat M Usmanov*** (shukhrat.usmanov@ashford.edu), Ashford University, College HHSS, 400 North Bluff Blvd, Clinton, IA 52732. *A functional representation of commutative symmetrical algebras, possessing an eigen-vector and acting on the Pontryagin Π_1 space*. Preliminary report.

It is well known fact that in Pontryagin Π_1 space with an indefinite metric all weakly closed algebras of bounded operators can be classified by 6 types (models): types 0, I, II_a, II_b, III_a, III_b, according to work of V. S. Shulman (Mat. Sbornik, 1972, 89, No 2). We are proving that only types 0, I, II_a and III_a could be represented as commutative symmetrical algebras. After that, we are stating and proving the theorem of functional representation for three types: 0, II_a and III_a. For type I the theorem had proven for the case of a single operator. The problem of constructing a functional representation for an arbitrary algebra of type I (in Shulman's classification) is still open. (Received September 23, 2012)

1086-46-1670 **J William Helton***, Math Dept, UC San Diego, La Jolla, CA 92093, and **Scott A McCullough**, Math Dept, U of Florida, Gainesville, FL 32603. *Noncommutative Inequalities*. Preliminary report.

Noncommutative Inequalities

J. William Helton and Scott A McCullough

The talk concerns inequalities for non-commutative functions. At this point we have for free $*$ -algebras:

A. versions of the classical real algebraic geometry description of when one polynomial p is nonnegative on the domain where another polynomial q is nonnegative. Recent advances are in conjunction with Igor Klep and Chris Nelson.

B. classification of convex non-commutative polynomials, rational functions and varieties. There are shockingly few of these.

C. Some theory of changes of variables to achieve non-commutative convexity (due to Helton Klep McCullough Popescu).

D. other.

The talk will select a topic from this. The work originates in trying to develop some theory for studying the matrix inequalities which are ubiquitous in linear engineering systems and control. (Received September 24, 2012)

1086-46-1954 **Alice Guionnet** and **Dimitri Shlyakhtenko*** (shlyakht@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095. *Free monotone transport.*

By solving a free analog of the Monge-Ampere equation, we prove a non-commutative analog of Brenier's monotone transport theorem: if an n -tuple of self-adjoint non-commutative random variables Z_1, \dots, Z_n satisfies a regularity condition then there exist invertible non-commutative functions F_j of an n -tuple of semicircular variables S_1, \dots, S_n , so that $Z_j = F_j(S_1, \dots, S_n)$. Moreover, F_j can be chosen to be monotone, in the sense that $F_j = D_j g$ and g is a non-commutative function with a positive definite Hessian. In particular, we can deduce that $C^*(Z_1, \dots, Z_n) \cong C^*(S_1, \dots, S_n)$ and $W^*(Z_1, \dots, Z_n) \cong L(F(n))$. We obtain as a consequence that the q -deformed free group factors $\Gamma_q(R^n)$ are isomorphic (for sufficiently small q , with bound depending on n) to free group factors. We also partially prove a conjecture of Voiculescu by showing that free Gibbs states which are small perturbations of a semicircle law generate free group factors. Lastly, we show that entrywise monotone transport maps for certain Gibbs measure on matrices are well-approximated by the matricial transport maps given by free monotone transport. (Received September 24, 2012)

1086-46-2159 **Stephen R Curran*** (curransr@math.ucla.edu), Dept. of Mathematics, UCLA, 520 Portola Plaza, Los Angeles, CA 90095. *Free probability and planar algebras.*

In 2008, Guionnet, Jones and Shlyakhtenko gave a diagrammatic construction of a subfactor, starting from a planar algebra, by considering a natural random matrix model on the associated principal graph. In recent work with Jones and Shlyakhtenko, we have given a diagrammatic construction of Popa's symmetric enveloping algebra associated to these subfactors, and computed several related invariants. We will survey some of these developments. (Received September 24, 2012)

1086-46-2186 **Ami Viselter*** (viselter@ualberta.ca). *Locally compact quantum groups and amenability.*

We will begin by introducing the Kustermans-Vaes definition of locally compact quantum groups (LCQGs). Then, after reviewing the definition of amenability for locally compact groups, we will present its generalization(s) to LCQGs, and relate several problems of current research connected with these notions. (Received September 25, 2012)

1086-46-2274 **James A Mingo*** (mingo@mast.queensu.ca), Department of Mathematics and Statistics, Queen's University, Kingston, Ontario K7L 3N6, Canada, and **Mihai V Popa** (popa@mast.queensu.ca) and **C. Emily I. Redelmeier** (emily.redelmeier@math.u-psud.fr). *Second Order Freeness and Orthogonal Random Matrices.*

Second order freeness is a property exhibited by many ensembles of random matrices. In recent work with Mihai Popa and Emily Redelmeier we have shown that Haar distributed random orthogonal matrices are real asymptotically free of second order from independent and orthogonally invariant ensembles. (Received September 25, 2012)

1086-46-2327 **William W. Johnston*** (bwjohnst@butler.edu), Butler University, 4600 Sunset Avenue, Indianapolis, IN 46208. *An Alternate Proof that the Hermite Functions Form a Basis for $L^2(\mathbb{R})$.* Preliminary report.

The standard elegant but advanced proof that the Hermite functions $\{H_n(x)e^{-x^2/2}\}_{n=0}^\infty$ form an orthonormal basis for $L^2(\mathbb{R})$ traditionally proceeds by forming an associated complex function, proving it entire, and using its complex function theoretic properties (such as those following from an application of Liouville's theorem and the mean value theorem) to show the corresponding Fourier transform is zero almost everywhere. This presentation describes an alternative proof, which is an expansion of a method of Richard Wheeden and Antoni Zygmund that

they applied to $L^2(-\pi, \pi)$. This more basic technique uses real function descriptions of the Schwarz inequality and the fundamental theorem of calculus (on an infinite range of integration) as its most sophisticated tools. The proof is then accessible to undergraduate majors. (Received September 25, 2012)

1086-46-2422 **Alexandru Nica*** (anica@math.uwaterloo.ca), Pure Mathematics Department, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. *On the Hopf algebra approach to the S-transform.*

The S-transform is used in free probability in order to study multiplication of free random variables. In this talk I will discuss a Hopf algebra approach to the S-transform which was initiated in a 2010 paper by M. Mastnak and myself. (Received September 25, 2012)

1086-46-2552 **Sarah E. Wright***, College of the Holy Cross, One College Street, Worcester, MA 01610. *A Twisted Topological k -Graph and New Aperiodicity Conditions.*

This talk addresses a new type of topological k -graph constructed from a discrete k -graph and a continuous functor. We explore this idea as an interesting construction in its own right and see how it demonstrates the benefits gained from new aperiodicity conditions. (Received September 25, 2012)

1086-46-2666 **Robert Niedzialomski*** (robert-niedzialomski@uiowa.edu), 818 W Moss Ave Apt 11, Peoria, IL. *On extension of positive definite functions.*

Let $\Omega \subset \mathbb{R}^n$ be an open, symmetric, and convex subset of \mathbb{R}^n . We say that a function $f: \Omega \rightarrow \mathbb{C}$ is positive definite if for any $x_1, \dots, x_m \in (1/2)\Omega$ and any $c_1, \dots, c_m \in \mathbb{C}$ the following holds

$$\sum_{j,k=1}^m f(x_j - x_k) c_j \overline{c_k} \geq 0.$$

Let $f: \Omega \rightarrow \mathbb{C}$ be a continuous and bounded positive definite function with Ω being bounded. We will give necessary and sufficient conditions for f to have an extension to a continuous and bounded positive definite function defined on the entire Euclidean space \mathbb{R}^n . The conditions are formulated in terms of commutativity of some certain self-adjoint operators defined on the reproducing kernel Hilbert space associated to our positive definite function. This is joint work with Palle Jorgensen. (Received September 25, 2012)

1086-46-2838 **Antonio J. Guirao** and **Olena Kozhushkina*** (okozhush@math.kent.edu), Department of Mathematical Sciences, Kent State University, Kent, OH 44242. *On the Extension of the Bishop-Phelps-Bollobás Theorem.*

The Bishop-Phelps theorem states that the set of linear functionals that attain their norm is dense in the dual of a Banach space. The question of generalizing this result to the operators on Banach spaces has been of interest for almost fifty years and has been studied extensively. In 1970, B. Bollobás provided a quantitative extension of the Bishop-Phelps theorem. We investigate the Bishop-Phelps-Bollobás property for numerical radius. Also, we give a constructive proof of the Bishop-Phelps-Bollobás theorem for l_1 . (Received September 25, 2012)

47 ► Operator theory

1086-47-17 **Alice Guionnet***, Ecole Normale Supérieure de Lyon, Lyon, France. *Free probability, Random matrices and map enumeration, III.*

Random matrices can be used to represent loop models on planar maps, including for instance the Potts model on random planar maps or more generally tracial states on planar algebras. We shall discuss this connection in this talk (which will not require to have followed the first two talks). (Received April 10, 2012)

1086-47-188 **Omar Hirzallah** (o.hirzal@hu.edu.jo), Department of Mathematics, Hashemite University, Zarqa, Jordan, and **Fuad Kittaneh*** (fkitt@ju.edu.jo), Department of Mathematics, University of Jordan, Amman, Jordan. *Numerical radius inequalities for several operators.*

Let A, B, X , and A_1, \dots, A_{2n} be bounded linear operators on a complex Hilbert space. It is shown that

$$w\left(\sum_{k=1}^{2n-1} A_{k+1}^* X A_k + A_1^* X A_{2n}\right) \leq 2 \left(\sum_{k=1}^n \|A_{2k-1}\|^2\right)^{1/2} \left(\sum_{k=1}^n \|A_{2k}\|^2\right)^{1/2} w(X)$$

and

$$w(AB \pm BA) \leq 2\sqrt{2} \|B\| \sqrt{w^2(A) - \frac{\|\operatorname{Re} A\|^2 - \|\operatorname{Im} A\|^2}{2}},$$

where $w(\cdot)$ and $\|\cdot\|$ are the numerical radius and the usual operator norm, respectively. These inequalities generalize and refine some earlier results of Fong and Holbrook. Some applications of our results are given. (Received August 05, 2012)

1086-47-306 **Arkady K Kitover*** (akitover@ccp.edu), 12135 ACADEMY RD # 61, Philadelphia, PA 19154. *Commutants of multiplication operators and Michael selection theorem.*

We consider multiplication operators on the space $C(K)$ of all real-valued continuous functions on a compact Hausdorff space K assuming that K has no isolated points. Using Michael selection theorem we prove that if K is connected and locally connected then the double commutant of any such operator T coincides with operator norm closure of the algebra generated by T and the identity operator. We show that the condition that K is connected is necessary but not sufficient for the result above and the condition that K is connected and locally connected is sufficient but not necessary. (Received August 18, 2012)

1086-47-387 **Raul E. Curto**, Department of Mathematics, The University of Iowa, Iowa City, IA 52242, and **George R. Exner*** (exner@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837. *Finding some Berger measures.* Preliminary report.

The moments of a Hilbert space weighted shift W with weight sequence $\alpha_0, \alpha_1, \dots$ are defined by $\gamma_0 = 1$, $\gamma_k = \gamma_{k-1} \cdot \alpha_{k-1}^2$ ($k = 1, 2, \dots$). If W is subnormal it has a Berger measure (supported on $[0, \|W\|^2]$ and with moments matching the moments of W). We consider techniques for determining concretely the Berger measure for certain shifts known to be subnormal, illustrating with the surprising measure for the shift obtained by taking the square root of each weight of the familiar Bergman shift (which itself has the simple Berger measure $1 \cdot dt$ on $[0, 1]$). (Received August 28, 2012)

1086-47-529 **Lawrence A. Fialkow*** (fialkowl@newpaltz.edu). *Limits of positive flat bivariate moment matrices.*

Let $\overline{\mathcal{F}}_d$ denote the closure of the positive flat moment matrices of degree $2d$ in n real variables. Each matrix in $\overline{\mathcal{F}}_d$ admits computable approximate representing measures, and in previous work Jiawang Nie and the author began to study concrete conditions for membership in this class. Let $\beta \equiv \beta^{(2d)} = \{\beta_i\}_{i \in \mathbb{Z}_+^n, |i| \leq 2d}$, $\beta_0 > 0$, denote an n -dimensional real sequence of degree $2d$. If the corresponding moment matrix $M_d \equiv M_d(\beta)$ is the limit of a sequence of positive flat moment matrices $\{M_d^{(k)}\}$, i.e., $M_d^{(k)} \succeq 0$ and $\text{rank } M_d^{(k)} = \text{rank } M_{d-1}^{(k)}$, then i) $M_d \succeq 0$, ii) $\text{rank } M_d \leq \dim \mathbb{R}[x_1, \dots, x_n]_{d-1}$, and iii) $\beta^{(2d-1)}$ admits a representing measure. We extend the results of Nie and the author by proving, conversely, that for $n = 2$, if M_d satisfies i), ii), and a Hankel matrix condition related to iii), then M_d is the limit of positive flat moment matrices. (Received September 05, 2012)

1086-47-565 **Chang-Pao Chen*** (cpchen@mail.hcu.edu.tw), Center for general education, Hsuan Chuang University, Hsinchu, 30092, Taiwan, **Jin-Wen Lan**, Department of Mathematics, National Tsing Hua University, Hsinchu, 30013, Taiwan, and **Dah-Chin Luor**, Department of Applied Mathematics, I-Shou University, Kaohsiung, 84008, Taiwan. *Multidimensional extensions of Pólya-Knopp-type inequalities over spherical cones.* Preliminary report.

In this talk, we present a multidimensional extension of the Pólya-Knopp-type inequality for a general kernel. As a consequence, we prove that it includes the known results as special cases. We also point out that our estimates improve the known ones. (Received September 07, 2012)

1086-47-601 **David Gaebler*** (david-gaebler@uiowa.edu), 14 MacLean Hall, Iowa City, IA 52242. *Unital Dilations of Completely Positive Semigroups.*

Semigroups of completely positive maps on C^* -algebras arise in the dynamics of open quantum systems, and in the theory of noncommutative Markov processes. Several authors have studied how such a semigroup may be dilated to a semigroup of endomorphisms; however, the dilations achieved are generally non-unital, corresponding to the embedding of $B(H)$ as a corner of $B(K)$ for Hilbert spaces $H \subset K$. Jean-Luc Sauvageot's dilation theorem, published in 1986, achieves a unital dilation, but at the cost of important continuity properties. This talk will discuss Sauvageot's approach to dilation and its relationship to free probability and other subsequent developments. (Received September 08, 2012)

1086-47-611 **Paul Daniel Skoufranis*** (pskoufra@math.ucla.edu). *On a Notion of Exactness for Reduced Free Products of C^* -Algebras.*

We will study some modifications to the notion of an exact C^* -algebra by replacing the minimal tensor product with the reduced free product. First we will demonstrate how the reduced free product of a short exact sequence of C^* -algebras with another C^* -algebra may be taken. It will then be demonstrated that this operation preserves

exact sequences. We will also establish that adjoining arbitrary k -tuples of operators in a free way behaves well with respect to taking ultrapowers. (Received September 08, 2012)

1086-47-724 **Rod Freed*** (rfreed@csudh.edu), 4265 Marina City Drive #211, Marina del Rey, CA 90292. *An Isomorphism Between the Ranges of Two Representations.*

Let f be a continuous linear isomorphism of one C^* algebra, A , into another C^* algebra, B . Let g and h be the universal representations of A and B . First, we show that $g \circ \text{foinv}(h)$ (where " \circ " denotes composition) extends to a linear isomorphism of the closure of $g(A)$ onto the closure of $h(B)$. Then we show that this isomorphism is a Jordan $*$ -isomorphism if f is a Jordan $*$ -isomorphism. (Received September 11, 2012)

1086-47-853 **Nicholas Young***, School of Mathematics and Statistics, Newcastle University, Newcastle upon Tyne, NE1 7RU, United Kingdom. *Generalized models and slope functions for the Schur class of the bidisc.*

If a function f in the Schur class of the bidisc \mathbb{D}^2 satisfies Carathéodory's condition at $\tau \in \mathbb{T}^2$ then f has a directional derivative at τ in every direction that points into the bidisc. This derivative can be expressed in terms of an analytic function in the Stieltjes class called the slope function of f at τ . We ask: does every function in the Stieltjes class arise as the slope function of some function in the Schur class?

To this end we generalize the notion of a model of f , that is, a triple (H, P, u) where H is a separable Hilbert space, P is a Hermitian projection on H and $u : \mathbb{D}^2 \rightarrow H$ is a map such that, for all $z, w \in \mathbb{D}^2$,

$$1 - \overline{f(w)}f(z) = \langle (1 - w_P^* z_P)u(z), u(w) \rangle_H$$

and

$$z_P = z_1 P + z_2 (1 - P).$$

In a *generalized model* of f we replace the linear function $z \mapsto z_P$ by a general contractive analytic operator-valued function on \mathbb{D}^2 . We prove that generalized models with certain regularity properties exist, and with their aid we are able to use an integral representation of functions in the Stieltjes class to show that the answer to the question is yes.

This is joint work with Jim Agler and Ryan Tully-Doyle. (Received September 14, 2012)

1086-47-860 **Derek A Thompson*** (theycallmedt@gmail.com), Derek Thompson, 4253 Willow Bend Dr., Apt. D, Beech Grove, IN 46107. *Restrictions of Composition Operators to Invariant Subspaces.* Preliminary report.

If ϕ is an analytic map of the unit disk into itself, the composition operator C_ϕ is the operator on the Hardy space H^2 given by $C_\phi f = f \circ \phi$. Though we have learned much about composition operators and their effect on spaces of analytic functions, little is still known about the restrictions of these operators to invariant subspaces. For example, when the symbol of a composition operator on the Hardy space of the disk fixes the origin, the subspaces resulting from the (right) unilateral shift are all invariant for the operator. What are the norms of these restrictions? What are their spectra? Are they ever unitarily equivalent? We disprove unitary equivalence in particular cases and explore the possibility in others. (Received September 14, 2012)

1086-47-1032 **Nikolai Vasilevski*** (nvasilev@math.cinvestav.mx), Department of Mathematics, CINVESTAV, Av. Instituto Politecnico Nacional 2508, Col. San Pedro Zacatenco, 07360 Mexico, D.F., Mexico. *Commutative algebras generated by Toeplitz operators on the unit ball.*

We give the description and classification of the commutative C^* and Banach algebras generated by Toeplitz operators acting on weighted Bergman spaces on the unit ball. (Received September 18, 2012)

1086-47-1087 **Zeljko Cuckovic** and **Trieu Le*** (trieu.le2@utoledo.edu). *Asymptotic Toeplitzness of composition operators.* Preliminary report.

In the early eighties, Barria and Halmos introduced the notion of asymptotic Toeplitzness of operators on the Hardy space H^2 of the unit circle. Recently Nazarov and Shapiro investigated the problem of characterizing composition operators on H^2 which are asymptotically Toeplitz. Their studies led to interesting results and open problems. In this talk, we shall discuss the situation for composition operators on the Hardy space of the unit sphere. (Received September 18, 2012)

1086-47-1106 **Raul E. Curto*** (raul-curto@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *Generating tuples associated with Reinhardt domains in \mathbb{C}^n .*

In joint work with Sameer Chavan, we consider an abstract framework to study generating m -tuples, and use it to analyze hypercontractivity and hyperexpansivity in several variables. These two notions encompass

hyponormality and subnormality, as well as toral and spherical isometries; for instance, the Drury-Arveson 2-shift is a spherical complete hyperexpansion.

Our framework allows us to look at operator tuples associated with domains in \mathbb{C}^n . For example, for a 2-tuple (T_1, T_2) acting on a Hilbert space \mathcal{H} , and the Reinhardt domain

$$\{(z, w) \in \mathbb{C}^2 : |z|^2 + |w|^4 < 1\},$$

the generating 1-tuple is given by

$$Q(X) := T_1^* X T_1 + T_2^{*2} X T_2^2 \quad (X \in B(\mathcal{H})).$$

We show that every completely hyperexpansive generating tuple can be associated with a canonical 1-variable unilateral weighted shift; in the specific case of the Drury-Arveson 2-shift, this leads to the Dirichlet shift. We obtain a dilation theorem for a subclass of completely hyperexpansive generating tuples which includes, in particular, 2-isometric ones. Our proof is based on Stinespring's dilation theorem and a suitable Lévy-Khinchin representation formula. (Received September 18, 2012)

1086-47-1129 **Anatolii Grinshpan, Dmitry S Kaliuzhnyi-Verbovetskyi and Hugo J Woerdeman*** (hugo@math.drexel.edu), Department of Mathematics, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104. *Norm-Constrained Determinantal Representations of Multivariable Polynomials.*

For every multivariable polynomial p , with $p(0) = 1$, we construct a determinantal representation, $p = \det(I - KZ)$, where Z is a diagonal matrix with coordinate variables on the diagonal and K is a complex square matrix. Such a representation is equivalent to the existence of K whose principal minors satisfy certain linear relations. When norm constraints on K are imposed, we give connections to the multivariable von Neumann inequality, Agler denominators, and stability. We show that if a multivariable polynomial q , $q(0) = 0$, satisfies the von Neumann inequality, then $1 - q$ admits a determinantal representation with K a contraction. On the other hand, every determinantal representation with a contractive K gives rise to a rational inner function in the Schur-Agler class. (Received September 19, 2012)

1086-47-1308 **Anna Skripka*** (skripka@math.unm.edu). *Perturbation of operator functions.*
The talk will discuss Taylor-like approximations for functions of operators. (Received September 21, 2012)

1086-47-1316 **James Carter*** (carter42@iupui.edu). *Commutants of composition operators on the Hardy space.* Preliminary report.

For ϕ a map of the unit disk into itself, the induced composition operator C_ϕ acts on the Hilbert space of analytic functions on the disk by $C_\phi f = f \circ \phi$. The composition operator is bounded and several properties of the operator can be deduced from the properties of the symbol ϕ . If $\phi_t = e^{-t}z + 1 - e^{-t}$ where $t > 0$, then $\phi_t(1) = 1$ and $\phi'_t(1) < 1$ and the induced composition operators are not compact, however the operators do form a semigroup. Given a bounded operator, A , the set of operators that commute with A is called the commutant of A and each such operator, B , satisfies the equation $AB = BA$. In the case where ϕ induces a compact composition operator, a complete characterization of the commutant is well-known. The definition of commutant can be extended to a set of operators and this talk will discuss which operators commute with every C_{ϕ_t} for $t > 0$ as well as some of the properties of the commuting operators. (Received September 21, 2012)

1086-47-1351 **Darren C. Ong*** (darren.ong@rice.edu), Mathematics Department MS136, Rice University, 6100 Main St, Houston, TX 77251-1892, and **Paul Munger**. *A formula for the resolvent of the doubly infinite CMV matrix.*

The doubly infinite CMV matrix is a unitary operator acting on $\ell^2(\mathbb{Z})$ that has recently emerged as a useful tool in the study of quantum random walks on the integers. For example, Cantero, Grünbaum, Moral and Velázquez have used it to discover results analogous to those that Karlin and McGregor developed to study classical birth-and-death processes. In our work, we exhibit an expression for the resolvent of the CMV matrix in terms of the resolvents of the two semi-infinite CMV matrices that comprise its two "halves". This expression is useful, because the semi-infinite CMV matrix is better understood than the doubly infinite CMV matrix, due to the fact that the semi-infinite CMV matrix has a stronger connection to the theory of Jacobi operators and orthogonal polynomials on the real line. We will also suggest applications of our formula in the study of quantum random walks. (Received September 21, 2012)

- 1086-47-1407 **John D Williams*** (jwilliams@math.tamu.edu), Texas A&M Dept. of Mathematics, Mailstop 3368, College Station, TX 77843-3368. *Limit theorems for monotonic convolution and the Chernoff product formula.*

Bercovici and Pata showed that the correspondence between classically, freely, and Boolean infinitely divisible distributions holds on the level of limit theorems. We extend this correspondence also to distributions infinitely divisible with respect to the additive monotone convolution. Because of non-commutativity of this convolution, we use a new technique based on the Chernoff product formula. We also study this correspondence for multiplicative monotone convolution, where the Bercovici-Pata bijection no longer holds. Joint with Michael Anshelevich. (Received September 21, 2012)

- 1086-47-1412 **Stephan Ramon Garcia*** (stephan.garcia@pomona.edu), Department of Mathematics, Pomona College, 610 N. College Ave, Claremont, CA 91711. *C^* -algebras generated by truncated Toeplitz operators.*

We discuss an analogue of Coburn's description of the Toeplitz algebra in the setting of *truncated Toeplitz operators*, a class of operators whose study has been largely motivated by a seminal 2007 paper of Sarason. As a byproduct, we are able to shed some light on the relationship between *complex symmetric operators* and truncated Toeplitz operators. This is joint work with William T. Ross and Warren R. Wogen. (Received September 21, 2012)

- 1086-47-1435 **Stephan Ramon Garcia*** (stephan.garcia@pomona.edu), Department of Mathematics, Pomona College, 610 N. College, Claremont, CA 91711. *Recent progress on complex symmetric operators.*

An operator T in $B(\mathcal{H})$ is a *complex symmetric operator* (CSO) if there exists a conjugate-linear, isometric, involution C such that $T = CT^*C$. This class is surprisingly large and contains, for instance, normal operators, Hankel operators, the Volterra integration operator, truncated Toeplitz operators, and many other examples. A number of years ago, Garcia and Wogen asked whether or not the set of all CSOs on an infinite-dimensional Hilbert space is closed in the operator norm. Recently, two very different solutions to this problem have emerged (by Garcia-Poore and Zhu-Ji-Li). We discuss these results and some of their implications, along with a rather surprising result about the "indestructibility" of certain nilpotent operators. (Received September 21, 2012)

- 1086-47-1510 **Serban Teodor Belinschi*** (sbelinsch@mast.queensu.ca), Department of Mathematics and Statistics, Queen's University, Jeffrey Hall, University Avenue, Kingston, Ontario K7L 3N6, Canada, and **Roland Speicher, John Treilhard** and **Carlos Vargas**. *Analytic subordination for multiplicative free convolution of operator-valued distributions.*

The analytic subordination phenomenon for free convolutions of operator-valued distributions has been discovered by Voiculescu in the early 2000s. Specifically, he proved that if X, Y are self-adjoint random variables in a tracial operator-valued non-commutative probability space $(\mathcal{M}, \mathbb{E}, B)$ which are free over B w.r.t. \mathbb{E} , then there exists a fully matricial self-map ω of the (fully matricial extension of the) upper half-plane of B so that $\mathbb{E}_{B[X]}[(b - X - Y)^{-1}] = (\omega(b) - X)^{-1}$ for all $b \in B$ with positive imaginary part, and all maps involved are fully matricial. In a later article, he extended this result to products XY of such random variables. Motivated by questions from random matrix theory, in joint work with Speicher, Treilhard and Vargas, we have devised an iterative process in the spirit of a previous result by Bercovici and the presenter that provides us with a fully matricial function ω satisfying

$$\mathbb{E}[(1 - bXY)^{-1}] = \mathbb{E}[(1 - \omega(b)Y)^{-1}], \quad \Im(bX) > 0.$$

Here $X > 0$ and $Y = Y^*$. Essential in our proof are Dykema's operator-valued S -transform and theory of analytic maps on Banach spaces. We conclude our talk with some applications to the computation of joint distributions of random matrices. (Received September 22, 2012)

- 1086-47-1512 **Travis Wolf*** (travs-wolf@uiowa.edu), Travis Wolf, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242-1419. *Coisometric Extensions of Completely Contractive Covariant Representations.* Preliminary report.

A C^* -correspondence E over a C^* -algebra A is a sort of generalized Hilbert space, together with a homomorphism $\phi : A \rightarrow \mathcal{L}(E)$ giving a left action of A on E , where $\mathcal{L}(E)$ denotes the C^* -algebra of bounded adjointable operators on E . A *generalized transfer operator* for ϕ is a completely positive linear map $\tau : \mathcal{L}(E) \rightarrow A$ with the property that $\tau(\phi(a)X) = a\tau(X)$ for $a \in A$ and $X \in \mathcal{L}(E)$. Assuming ϕ has a generalized transfer operator, we give a way of constructing a unique coisometric extension for any so-called *completely contractive covariant representation* of (E, A) . Completely contractive covariant representations are generalizations of contractive operators to the setting of C^* -correspondences, and in the course of the construction we will examine several examples. Notable

among them is the special case where $E = \mathbb{C}^d$ and $A = \mathbb{C}$, in which case a (unital) generalized transfer operator is simply a state on $M_d(\mathbb{C})$.

Our analysis extends work of Muhly and Solel and complements studies by Ball and Vinnikov, Bratteli and Jorgensen, Exel, and Popescu. (Received September 23, 2012)

1086-47-1554 **Mrinal Raghupathi*** (raghupat@usna.edu) and **Ryan Hamilton**. *The Toeplitz corona problem for algebras of multipliers on a Nevanlinna-Pick space.*

Suppose \mathfrak{A} is an algebra of operators on a Hilbert space H and $A_1, \dots, A_n \in \mathfrak{A}$. If the row operator $[A_1, \dots, A_n] \in B(H^{(n)}, H)$ has a right inverse in $B(H, H^{(n)})$, the Toeplitz corona problem for \mathfrak{A} asks if a right inverse can be found with entries in \mathfrak{A} . When H is a complete Nevanlinna-Pick space and \mathfrak{A} is a weakly-closed algebra of multiplication operators on H , we show that under a stronger hypothesis, the corona problem for \mathfrak{A} has a solution. When \mathfrak{A} is the full multiplier algebra of H , the Toeplitz corona theorems of Arveson, Schubert and Ball-Trent-Vinnikov are obtained. A tangential interpolation result for these algebras is developed in order to solve the Toeplitz corona problem. (Received September 23, 2012)

1086-47-1609 **Raul E. Curto*** (raul-curto@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *Multiplication operators on reproducing kernel Hilbert spaces on Reinhardt domains in \mathbb{C}^2 .*

Consider a reproducing kernel Hilbert space $H(K)$ on a bounded Reinhardt domain $\Omega \subset \mathbb{C}^2$, with kernel of the form $K(\mathbf{z}, \mathbf{w}) = \sum_{\mathbf{m} \in \mathbb{Z}_+^2} \frac{\mathbf{z}^{\mathbf{m}} \mathbf{w}^{\mathbf{m}}}{A_{\mathbf{m}}}$. Assume that the coordinate functions z_1 and z_2 are multipliers on $H(K)$. Assume further that $A_{m_1+1, m_2+1} = A_{1,1} \gamma_{m_1+m_2}[\alpha]$, where α is a bounded sequence of positive numbers and $\{\gamma_k\}_{k \geq 0}$ is the associated sequence of moments; that is, $\gamma_0[\alpha] := 1$, $\gamma_{k+1}[\alpha] := \alpha_k^2 \gamma_k[\alpha]$ ($k \geq 0$).

The pair $M_{\mathbf{z}} \equiv (M_{z_1}, M_{z_2})$ is thus a 2-variable weighted shift whose restriction to the invariant subspace $z_1 z_2 H(K)$ can be regarded as a 2-variable embedding of the unilateral weighted shift W_{α} . In joint work with S.H. Lee and J. Yoon, we study (joint) spectral and structural properties of $M_{\mathbf{z}}$ acting on $H(K)$. For instance, we prove that $M_{\mathbf{z}}$ is subnormal if and only if some integer power $M_{z_1}^{k_1} M_{z_2}^{k_2}$ is subnormal. (Received September 23, 2012)

1086-47-1712 **Jim Agler*** (jagler@ucsd.edu). *Nevanlinna Representations in Several Variables.*

In 1922, in a classic paper that solved the problem of the determinacy of solutions to the Stieltjes moment problem, Nevanlinna established the following characterization of the Cauchy Transforms of finite positive Borel measures on the real line.

Nevanlinna's Representation. Let $\Pi = \{z \in \mathbb{C} \mid \operatorname{Im} z > 0\}$ and let h be a complex valued function defined on Π . There exists a finite positive Borel measure μ that is supported in \mathbb{R} and such that

$$h(z) = \int \frac{1}{t-z} d\mu$$

for all $z \in \Pi$ if and only if h is analytic on Π , $\operatorname{Im} h(z) > 0$ for all $z \in \Pi$, and

$$\liminf_{y \rightarrow \infty} y|h(iy)| < \infty.$$

We shall describe how this theorem and other closely related theorems can be generalized to several variables using operator-theoretic methods. The results are drawn from a number of papers written jointly with Ryan Tully-Doyle, John McCarthy and Nicholas Young. (Received September 24, 2012)

1086-47-1717 **Dan D. Pascali*** (dp39@nyu.edu), 251 Mercer Street, New York, NY 10012-1185. *On a sharpened form of Leray-Lions ellipticity criterion.*

The well-known ellipticity criterion of Leray-Lions for solvability of the nonlinear equation in divergence form is sharpened, eliminating any coercivity hypothesis, by using a remark on the asymptotic strong monotonicity of strictly monotone mappings in a finite-dimensional space, and extending the result to non-local mappings. (Received September 24, 2012)

1086-47-1894 **Antonia E. Cardwell*** (antonia.cardwell@millersville.edu), Department of Mathematics, Millersville University, P. O. Box 1002, Lancaster, PA 17551. *A weakly dense sequence that is not norm dense.*

A bounded linear operator $T: X \rightarrow X$ is said to be (norm) hypercyclic if there is a vector $x \in X$ such that the orbit $\operatorname{Orb}(T, x) = \{x, Tx, T^2x, \dots\}$ is norm-dense in X . An operator $T: X \rightarrow X$ is said to be weakly hypercyclic if there is a vector $x \in X$ such that the orbit is dense in X with respect to the weak topology. As the norm topology is stronger than the weak topology, every norm hypercyclic operator is weakly hypercyclic. In 2002, N. S. Feldman posed the question of whether every weakly hypercyclic operator is also (norm) hypercyclic. In 2004,

K. Chan and R. Sanders gave a sufficient condition for a bilateral weighted shift on $\ell_p(\mathbf{Z})$ ($2 \leq p < \infty$) to be weakly hypercyclic (but not norm hypercyclic), giving a negative answer to Feldman's question. The question then arises of which spaces support such operators. The question can be rephrased to ask in which spaces there exists a sequence that is weakly dense but not norm dense. We construct such a sequence, first for the spaces $\ell_p(\mathbf{N})$ ($1 < p < \infty$), and then for certain spaces with a shrinking, monotone basis whose dual space has an unconditional basis. (Received September 24, 2012)

1086-47-2032 **Mihai Popa*** (popa@mast.queensu.ca), Department of Mathematics, Queen's University, Jeffery Hall, 1 University Ave, Kingston, Ontario K7L 3N6, Canada. *Hardy classes on non-commutative unit ball.*

The talk will present some results, joint work with V. Vinnikov, in the study of the Hardy space H^2 of locally bounded non-commutative functions on the non-commutative unit ball of a variety of finite dimensional operator spaces. Our methods combine the general theory of non-commutative functions with asymptotic freeness results of D.-V. Voiculescu and formulas for integration over unitary groups of B. Collins and P. Sniady. (Received September 24, 2012)

1086-47-2292 **Michael Jury*** (mjury@ufl.edu), PO Box 118105, Gainesville, FL 32611-8105. *Rank-one perturbations of Cuntz isometries.* Preliminary report.

Cuntz isometries are d -tuples (V_1, \dots, V_d) of operators on Hilbert space H obeying the relations $V_i^* V_j = \delta_{ij}$, $\sum V_i V_i^* = I$. The row (V_1, \dots, V_d) implements a unitary operator from $\bigoplus_{j=1}^d H$ to H . We consider families of rank-one perturbations of such "row unitaries," and describe their connections with multipliers of the Drury-Arveson space H_d^2 , deBranges-Rovnyak subspaces of H_d^2 , and the Gleason problem in these subspaces. A central role is played by the "mixed" characteristic function associated to the perturbed tuple. (Received September 25, 2012)

1086-47-2424 **William Benjamin Grilliette*** (w.b.grilliette@gmail.com), 203 Eden Drive, Apartment 217, Longview, TX 75605. *Scaled-Free Properties for Matrix-Normed Objects.* Preliminary report.

This talk continues the study of the scaled-free mapping property, an extension of the free mapping property to normed-objects. Here, I devise an "array-weighted set" and associated categories, which are then used to construct of matrix-normed objects. Much like sets in the natural algebraic constructions, this class of objects is used as a base to build matrix-normed vector spaces and algebras, including operator spaces and algebras, with a scaled-free mapping property. (Received September 25, 2012)

1086-47-2645 **Craig Kleski*** (ckleski@virginia.edu). *Extreme points of some noncommutative convex sets.*

Recent results on boundary representations for separable operator systems yield new information about extreme points for matrix convex sets associated to such operator systems. For a matrix convex set K , we introduce a new notion of extremeness for K that corresponds exactly to the boundary representations for the associated operator system $A(K)$, when $A(K)$ is in a matrix algebra. In this case, we can improve the Webster-Winkler Krein-Milman theorem. We also show how boundary representations are related to Morenz's Krein-Milman theorem for compact C^* -convex sets in M_n . (Received September 25, 2012)

1086-47-2840 **Mehdi Nikpour*** (mnikpour@auaf.edu.af). *Asymptotic Toeplitzness of Composition operators and their adjoints.*

Building on techniques developed by Cowen and Nazarov-Shapiro, it is shown that the adjoint of a composition operator, induced by a unit disk-automorphism, is not strongly asymptotically Toeplitz. This result answers Nazarov-Shapiro's question. In the other direction, we study the asymptotic Toeplitzness of the product of a composition operator with its adjoint. (Received September 25, 2012)

49 ► *Calculus of variations and optimal control; optimization*

1086-49-32 **N.U AHMED*** (ahmed@site.uottawa.ca), Professor N.U.Ahmed, EECS, University of Ottawa, Ottawa, Ontario K1N6N5, Canada, and **Charalambos Charalambos** (chadcha@ucy.ac.cy), Professor C.D. Charalambos, Nicosia, Cyprus. *Minimum Principle for Stochastic Differential Equations Subject to Continuous Diffusion and Lévy Process and Governed by Relaxed Controls.*

In this paper we consider non convex control problems of stochastic differential equations driven by relaxed controls. Let $(\Omega, \mathcal{F}, \mathcal{F}_t, P)$ denote a complete filtered probability space with $\mathcal{F}_t, t \geq 0$, denoting a complete filtration contained in \mathcal{F} satisfying right continuity and possessing left limits. Let $W \equiv \{W(t), t \geq 0\}$ denote an R^m valued Brownian motion and $\{q(dt \times dv)\}$ a random counting measure all adapted to the sigma algebra \mathcal{F}_t . The system model is given by

$$dx = b(t, x, u_t)dt + \sigma(t, x, u_t)dW + \int_{R^n \setminus \{0\}} C(t, x, v, u_t)q(dt \times dv), x(0) = x_0 \quad (1)$$

where for any function f we write

$$f(t, x, u_t) \equiv \int_U f(t, x, \xi)u_t(d\xi)$$

for any $\mathcal{M}_1(U)$ (probability measure) valued random process $u_t, t \geq 0$. The cost functional is given by

$$J(u) = \mathcal{E} \left\{ \int_0^T \ell(t, x, u_t)dt + \Phi(x(T)) \right\}. \quad (2)$$

The objective is to find a relaxed (measure valued) control that minimizes the functional J . We present existence of optimal controls and then develop necessary conditions of optimality. We cover both continuous diffusion and Jump processes. (Received June 04, 2012)

1086-49-192 **Gerard Brunick***, brunick@pstat.ucsb.edu, and **Mihai Sirbu** and **Karel Janecek**. *Optimal Investment in the Presence of High-water Mark Fees.*

In this talk, we will consider the problem of optimal asset allocation for an agent who may invest in a money market fund, a stock, and a hedge fund. We model the risky assets as correlated geometric Brownian motions and we assume that our investor maximizes discounted CRRA utility from consumption on an infinite horizon. We further suppose that the investment in the hedge fund is subject to a proportional performance fee that is assessed each time the cumulative profit-to-date derived from the investment in the hedge fund reaches a new running maximum. We will see that this problem reduces to the optimal control of a reflected diffusion. We will examine the regularity of the associated Hamilton-Jacobi-Bellman equation and show the existence of optimal controls. Finally, we will examine some qualitative properties of the optimal investment strategy. (Received August 06, 2012)

1086-49-195 **Glenn Sidle*** (sidleg@duq.edu), 440 College Hall, Department of Math and Computer Science, Duquesne University, Pittsburgh, PA 15282, and **Katie Heaps**, **Josh Koslosky** and **Stacey Levine**. *Fusing Images with Multiple Degradations Using Gaussian Mixture Models*. Preliminary report.

In recent years, many image processing tasks have been solved by finding optimal sparse image representations in a (possibly redundant) dictionary. Yu, Sapiro, and Mallat have shown that related representations can be found by estimating image patches using Gaussian Mixture Models (GMMs). In this talk we demonstrate how the GMM approach can be applied to solve the image fusion problem, focusing on noisy/blurry pairs, image zooming, and exposure bracketing. In addition, we will discuss how spatially adaptive smoothing can be used to enhance results depending on varying noise levels and geometric features such as edges and smooth regions. (Received August 06, 2012)

1086-49-271 **Boris Mordukhovich** and **Nghia Tran*** (nghia@math.wayne.edu), 1150 FAB, 656 W. Kirby, Detroit, MI 48202. *Second-order variational analysis and characterizations of tilt-stable optimal solutions in finite and infinite dimensions.*

The paper is devoted to developing second-order tools of variational analysis and their applications to characterizing tilt-stable local minimizers of constrained optimization problems in finite-dimensional and infinite-dimensional spaces. The importance of tilt stability has been well recognized from both theoretical and numerical aspects of optimization. Based on second-order generalized differentiation, we obtain qualitative and quantitative characterizations of tilt stability in general frameworks of constrained optimization and establish its

relationships with strong metric regularity of subgradient mappings and uniform second-order growth conditions. The results obtained are applied to deriving new necessary and sufficient conditions for tilt-stable minimizers in problems of nonlinear programming with twice continuously differentiable data in Hilbert and Euclidean spaces. (Received September 07, 2012)

1086-49-283 **Heinz H. Bauschke, Russell Luke and Hung M. Phan***, hungm.phan@yahoo.com, and **Xianfu Wang**. *Restricted Normal Cones: Basic Properties and Applications*.

In this talk, we introduce the restricted normal cone, which is a novel generalization of the Mordukhovich (also known as basic or limiting) normal cone. Basic properties are presented. In the case of subspaces, we make a connection to the Friedrichs angle between the subspaces. Restricted normal cones are useful in extending the work by Lewis, Luke and Malick on the method of alternating projections for two (possibly nonconvex) sets. An application to the problem of sparse optimization will also be presented. (Received August 15, 2012)

1086-49-295 **Annika L Jersild***, CSU 4452 PO Box 8795, Williamsburg, VA 23187, and **Padmanabhan Seshaiyer**. *A Computational Algorithm for Estimating Conductivities*. Preliminary report.

Inverse conductivity problems are widely applicable in many real-world problems such as groundwater flow and geothermal applications. One of the challenges in this area for scientists and researchers has been to develop efficient computational algorithms to estimate conductivity values that correspond to information underground through discrete data collected on the surface. In this work, we develop a computational algorithm that employs minimization of a cost function defined using the discrete data in conjunction with the solution to a coupled primal-dual formulation. The mathematical tools used in this research include the finite difference method, the steepest descent algorithm, Reisz representation theorem and definition of directional derivatives that help to formulate a unified computational algorithm to solve for the conductivities. Numerical results that validate the performance of the algorithm will be presented. (Received August 16, 2012)

1086-49-411 **Narayan Thapa*** (narayan.thapa@minotstateu.edu), 500 University Avenue West, Minot, ND 58707. *Regularization for Second Order Hyperbolic Partial Differential Equation with Neumann Boundary Condition*.

Regularization is a fundamental technique in the processing of measurement data. Thus it provides an opportunity to investigate key properties, the continuity and the differentiability, of solution with respect to parameters. In this paper, we study regularized approach to a nonlinear hyperbolic partial differential equation with Neumann boundary condition. Weakly Gâteaux differentiability of solution maps are shown on the admissible set of parameters. Gâteaux differentiability of objective map and convergence of regularized solution to the non regularized solution are established. (Received August 30, 2012)

1086-49-505 **Irene Fonseca*** (fonseca@andrew.cmu.edu), Department of Math. Sciences, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213. *Variational Methods for Crystal Surface Instability*.

Using the calculus of variations it is shown that important qualitative features of the equilibrium shape of a material void in a linearly elastic solid may be deduced from smoothness and convexity properties of the interfacial energy.

In addition, short time existence, uniqueness, and regularity for an anisotropic surface diffusion evolution equation with curvature regularization are proved in the context of epitaxially strained two-dimensional films. This is achieved by using the H^{-1} -gradient flow structure of the evolution law, via De Giorgi's minimizing movements. This seems to be the first short time existence result for a surface diffusion type geometric evolution equation in the presence of elasticity. (Received September 05, 2012)

1086-49-543 **Dumitru Motreanu*** (motreanu@univ-perp.fr), University of Perpignan, Department of Mathematics, 66680 Perpignan, France. *Minimizers related to nonlinear Neumann boundary value problems*.

In this work we study the minimizers and, generally, the critical points of the energy functional corresponding to a quasilinear elliptic equation with Neumann boundary condition on a bounded domain. The principal part of the equation is driven by a nonlinear operator in divergence form which is more general than the p-Laplacian. In particular, no homogeneity condition is required. Among the results that are presented here, we mention the basic property regarding the smooth and Sobolev local minimizers in our setting of Neumann problems. Nonlinear eigenvalues problems associated with the stated equation are also discussed. (Received September 06, 2012)

1086-49-592 **Ivan Ginchev Ivanov*** (iivanov1@iit.edu), Illinois Institute of Technology, 10 West 32-nd Street, E1 Building, Room 116a, Chicago, IL IL 60616, and **Denitza Gintcheva** (gintcheva@math.rochester.edu), UR Mathematics, 915 Hylan Building, RC Box 270138, Rochester, NY NY 14627. *Characterization and recognition of d.c. functions.*

A function $f : \Omega \rightarrow \mathbb{R}$, where Ω is a convex subset of the linear space X , is said to be d.c. (difference of convex) if $f = g - h$ with $g, h : \Omega \rightarrow \mathbb{R}$ convex functions. While d.c. functions find various applications, especially in optimization, the problem to characterize them is not trivial. The guideline characterization in this paper is relatively simple, but useful in various applications. For example, we use it to prove that piecewise affine functions in an arbitrary linear space are d.c.. Additionally, we give new proofs to the known results that $C^{1,1}$ functions and lower- C^2 functions are d.c.. The main goal remains to generalize to higher dimensions a known characterization of d.c. functions in one dimension: A function $f : \Omega \rightarrow \mathbb{R}$, $\Omega \subset \mathbb{R}$ open interval, is d.c. if and only if on each compact interval in Ω the function f is absolutely continuous and has a derivative of bounded variation. We obtain a new necessary condition in this direction. We prove an analogous sufficient condition under stronger hypotheses. The proof is based again on the guideline characterization. (Received September 07, 2012)

1086-49-594 **Feng Luo** (fluo@math.rutgers.edu) and **Tian Yang*** (tianyanyang@math.rutgers.edu). *Hyperbolic cone metrics on 3-manifolds with boundary.*

We prove that a hyperbolic cone metric on an ideally triangulated compact 3-manifold with boundary consisting of surfaces of negative Euler characteristic is determined by its combinatorial curvature. The proof uses a convex extension of the Legendre transformation of the volume function. Several related results on maximum volume angle structures are obtained. (Received September 07, 2012)

1086-49-616 **Irene Fonseca*** (fonseca@andrew.cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *Variational Methods in Materials Science and Image Processing.*

Several questions in applied analysis motivated by issues in computer vision, physics, materials sciences and other areas of engineering may be treated variationally leading to higher order problems and to models involving lower dimension density measures. Their study often requires state-of-the-art techniques, new ideas, and the introduction of innovative tools in partial differential equations, geometric measure theory, and the calculus of variations. In this talk it will be shown how some of these questions may be reduced to well understood first order problems, while in others the higher order terms play a fundamental role.

Applications to phase transitions, to the equilibrium of foams under the action of surfactants, imaging, micromagnetics, thin films, and quantum dots will be addressed. (Received September 09, 2012)

1086-49-633 **Mohsen Razzaghi*** (rzzaghi@math.msstate.edu), 410 Allen Hall, P.O. Drawer MA, Mississippi State, MS 39762. *Solution of Variational Problems by using a Hybrid Functions Approximation.*

In this work, we present a new direct computational method to solve variational problems. The approach is based on reducing the variational problems into a set of algebraic equations by first expanding the required solution as a hybrid function with unknown coefficient. These hybrid functions, which consist of block-pulse functions and Bernoulli polynomials are first introduced. Numerical examples are included to demonstrate the applicability and the accuracy of the proposed method and a comparison is made with the existing results. (Received September 09, 2012)

1086-49-896 **Ioan R Ionescu*** (ioan.r.ionescu@gmail.com), LSPM, University Paris 13, Sorbonne Paris Cit, 99 Av. J-B. Clement, 93430 Villetaneuse, France. *From Cheeger problem to limit analysis.*

The talk focuses on a new limit analysis method, called Discontinuous Velocity Domain Splitting method (DVDS). To solve the nonlinear PDE problem associated to ductile rupture (failure), DVDS considers a special class of velocity fields: the body is splinted into sub-domains animated by rigid motions. The collapse flow velocity field results in localized deformations only, located at the boundary of the sub-domains. The associated numerical technique is mesh free and its it based on a level set description of the partition and on genetic minimization algorithms.

For the scalar flow of a von-Mises material, DVDS is exact in solving the limit load problem. DVDS formulation reduces to the famous geometry problem of Cheeger, related to the eigenvalues of the Laplacian operator. One of the challenges is to know if these results are still valid in the vectorial case.

Two applications will be considered: dense avalanches onset of shallow natural structures and homogenization techniques for porous crystals. (Received September 15, 2012)

1086-49-925 **Lianwen Wang*** (lwang@ucmo.edu), Dept. of Mathematics and Computer Science, University of Central Missouri, Warrensburg, MO 64093. *Optimal Control of Neutral Functional Differential Inclusions.*

This paper deals with optimal control of neutral functional differential inclusions. First, a sequence of discrete optimization problems is constructed using discrete approximation. Then discrete necessary optimality conditions are obtained by means of variational analysis. After that, necessary optimality conditions for the original problem are derived from the discrete necessary optimality conditions. The necessary optimality conditions are expressed in terms of normal cones, subgradients, and coderivatives of nonconvex sets and set-valued mappings. (Received September 16, 2012)

1086-49-1083 **R. N. Mohapatra*** (ram.mohapatra@ucf.edu), University of Central Florida, Department of Mathematics, 4000 Central Florida Blvd., Orlando, FL 32816, and **R. U. Verma** (vermar@cmaaccess.com). *Generalized Higher-Order Univexities and Applications to Strongly Parametric Duality Models for Discrete Minimax Fractional Programming.*

Based on a significant generalization to higher order univexities, we investigate some strongly parametric duality models applied to establish some duality results to a semiinfinite minimax fractional programming problem. The results obtained encompass many of the duality results under various generalized higher order univexity assumptions available in the literature. (Received September 18, 2012)

1086-49-1138 **Alexander J Zaslavski*** (ajzasl@tx.technion.ac.il), Department Math. the Technion-IIT, 32000 Haifa, Israel. *The extragradient method for solving variational inequalities.*

In a Hilbert space, we study the convergence of the subgradient method to a solution of a variational inequality, under the presence of computational errors. Most results known in the literature establish convergence of optimization algorithms, when computational errors are summable. In this talk we show the convergence of the subgradient method for solving variational inequalities with nonsummable computational errors. We show that the subgradient method generates a good approximate solution, if the sequence of computational errors is bounded from above by a constant. (Received September 19, 2012)

1086-49-1145 **Mikil Foss and Joe Geisbauer*** (s-jgeisba1@math.unl.edu). *Extensions of variational methods to non-local functionals.* Preliminary report.

The applications of functionals with non-local integrands has recently become more prevalent, for example in peridynamics, biology, and image processing. As the regularity theory for local problems has been well developed, it is natural to investigate extensions of these regularity results to the non-local setting. In this talk, we will present some new results that provide the existence and increased differentiability, in the context of Besov Spaces, of minimizers for certain non-local functionals. (Received September 19, 2012)

1086-49-1153 **Ahmad R. Almomani*** (almomaar@clarkson.edu), Clarkson University, 8 Clarkson Ave. Box 5815, Mathematics Department, Potsdam, NY 13699, and **Katie R. Fowler** (kfowler@clarkson.edu). *Constraint Handling for Local and Global Derivative-Free Optimization methods.*

Derivative-free optimization is an alternative design method for problems where gradient information is unavailable or unreliable. This is often this case in real-world applications. The presence of constraints adds difficulties the search space has to be restricted to a feasible region. We consider constraint handling for (DFO) to local and global methods like Implicit Filtering (IF), Nelder-Mead (NM) for local and Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Simulating Annealing (SA), DIRECT algorithm for global with the standard penalty method for handling constraints. We introduce a new algorithm for local method that combine filter method for constraints with implicit filtering method and with (PSO) for global method. We consider a suite of test problems that include low and high amplitude noise, and some higher dimensional problems. Performance and data profiles can help understand algorithm performance and guide users when choosing a solution approach. (Received September 19, 2012)

- 1086-49-1186 **Hijran Mirzayeva*** (hijranmirzayeva@students.ballarat.edu.au), University Drive, Mt Helen, PO Box 663, Ballarat, Ballarat, Victoria 3353, Australia. *On extremum problem with constraints for discrete inclusions.*

The paper considers an extremum problem with constraints for discrete inclusions. The necessary extremum conditions are obtained for nonconvex extremum problem. It is shown the necessary conditions also are sufficient for regular convex extremum problem. This problem is reduced to the mathematical programming problem and the necessary extremum conditions are obtained using the nonsmooth analysis. (Received September 19, 2012)

- 1086-49-1194 **Mahdi Zarei*** (mahdizarei@students.ballarat.edu.au), University drive, Mount Helen, PO Box 663, Ballarat, Victoria 3353, Australia, and **Hijran Mirzayeva** (hijranmirzayeva@students.ballarat.edu.au), University drive, Mount Helen, PO Box 663, Ballarat, Victoria 3353, Australia. *Optimization of classifiers' parameters based on pso/sa algorithms for classification of fMRI data.*

Determining classifiers' parameters is one of the scientific challenges. This paper reports a novel hybrid optimization algorithm for optimization of classifiers' parameters. Proposed algorithm finds optimal values of discrete and continuous parameters of classifier using particle swarm optimization algorithm and simulated annealing algorithms. We apply the proposed algorithm to an fMRI data set and compare it with other algorithms. (Received September 20, 2012)

- 1086-49-1306 **Mau Nam Nguyen*** (mau.nam.nguyen@pdx.edu), Fariborz Maseeh Department of Math & Stats, Neuberger Hall, Room 334, 725 SW Harrison Street, Portland, OR 97201. *Variational Analysis of Directional Minimal Time Functions and Applications.*

In this talk, we will present our new results on variational analysis of directional minimal time functions that specify the minimal time for a vector to reach an object following its given direction. We will provide a careful analysis of general and generalized differentiation properties of this class of functions. The analysis allows us to study a new model of facility location that involves sets.

(This talk is based on joint work with C. Zalinescu) (Received September 21, 2012)

- 1086-49-1328 **Gamal N Elnagar*** (gelnagar@uscupstate.edu), 800 University Way, Spartanburg, SC 29303. *Delayed Functional Differential Equation Control Systems: A Spectral Optimization Approach.*

The spectral method of G. N. Elnagar, which yields spectral convergence rate for the approximate solutions of Volterra-Hammerstein integral equations, is generalized in order to solve the class of time-delayed functional differential equation control systems with spectral accuracy. The proposed method is based on the idea of relating spectrally constructed grid points to the structure of projection operators which will be used to approximate the control vector and the associated state vector. The problem is first formulated as a delay free optimal control problem governed by integral equation and a system of PDEs with nonlocal boundary conditions. Due to its dynamic nature, the proposed method avoids many of the numerical difficulties typically encountered in solving standard time-delayed functional differential equation control systems. (Received September 21, 2012)

- 1086-49-1384 **Mark A Allen*** (allenma@math.purdue.edu). *Separation of a Lower Dimensional Free Boundary in a Two Phase Problem.*

The author studies the two phase problem of a free boundary problem involving the fractional laplacian. This is a non-local analogue of a classical free boundary problem. The main result states that the two free boundaries of the positive and negative phases cannot touch. As a corollary, locally the free boundary problem reduces to a one phase problem. This result is in complete contrast to the classical free boundary problem where the two phases can touch. (Received September 21, 2012)

- 1086-49-1418 **Qiang Du*** (qdu@math.psu.edu), Department of Mathematics, Pennsylvania State University, University Park, PA 16802. *Nonlocal calculus and its applications to nonlocal models.*

In this talk, we discuss various features of a nonlocal vector and exterior calculus which is motivated from the mathematical studies of nonlocal peridynamic models. We discuss how they can be applied to formulate and analyze volume constrained problems. We also consider the analysis of numerical discretizations within this nonlocal framework. The talk is based on joint works with various collaborators including M. Gunzburger, R. Lehoucq, L. Ju, L. Tian, T. Mengesha, X. Zhao, K. Zhou, T. Le, Z. Huang and X. Tian. (Received September 21, 2012)

1086-49-1449 **Giovanni Leoni*** (giovanni@andrew.cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *A continuum model for epitaxial growth with elasticity on vicinal surfaces.*

In this talk we discuss existence of weak solutions of a variational inequality derived from the continuum model introduced in recent papers by Xiang and by Xiang and E to describe the self-organization of terraces and steps driven by misfit elasticity between a film and a substrate in heteroepitaxial growth. This model is obtained as a continuum limit of discrete theories of Duport, Politi, and Villain and of Tersoff, Phang, Zhang, and Lagally. This is joint work with G. Dal Maso and I. Fonseca. (Received September 22, 2012)

1086-49-1528 **Asen L Dontchev*** (ald@ams.org). *Dennis-Moré theorem revisited.*

We present several generalizations of the Dennis-Moré theorem characterizing superlinear convergence of quasi-Newton methods. Our first characterization does not impose differentiability and employs instead strong metric subregularity of the function involved. Then we give a Dennis-Moré theorem for nonsmooth functions. Finally, we present a Dennis-Moré theorem for generalized equations. (Received September 23, 2012)

1086-49-1558 **Andrew Gard*** (acgard@owu.edu). *Reverse Isoperimetric Inequalities in \mathbb{R}^3 .*

We investigate conditions under which the classical isoperimetric inequality can be reversed. Under appropriate restrictions, most essentially a bound on curvature, we show that volume can be minimized among embedded spheres of common surface area. In at least one case, the unique minimizer is explicitly constructed. (Received September 23, 2012)

1086-49-1568 **Jian Geng*** (jgeng@math.fsu.edu), **Michael I. Navon** and **Xiao Chen**. *Non-parametric calibration of the local volatility surface for European options.*

In this paper, we explore a robust method for calibration of the local volatility surface for European options across all strikes and maturities of the same underlying. Assuming the the volatility surface is smooth, we apply a second order Tikhonov regularization to the calibration problem. Additionally we propose a new approach for choosing the Tikhonov regularization parameter, which leads to an automatic convergence property. Automatic differentiation tool is employed as an efficient way to obtain the gradient of cost function with respect to the local volatility surface. Finally we perform numerical tests with respect to both theoretical volatility models with known analytic solutions of European option prices and true options data from the market. For all the theoretical models, we can successfully recover the true volatility surface. For the real market data, which includes equity index options and options in the FX market, the proposed method works equally well. (Received September 23, 2012)

1086-49-1581 **Rongjie Lai***, 3620 S. Vermont Ave., KAP 104, Los Angeles, CA 90089, and **Stanley Osher**. *A Splitting Method for Orthogonality Constrained Problems.* Preliminary report.

Orthogonality constrained problems are widely used in science and engineering. However, the non-convex constraint is a big challenge to solve the problems efficiently. In this talk, a splitting method will be represented to tackle the optimization problems with orthogonality constraints. Using the proposed method, the constrained problems can be iteratively solved by computing corresponding unconstrained problems and constrained quadratic problems with analytic solutions. As numerical experiments, we demonstrate the robustness and efficiency of our methods in several problems including constructing global conformal mapping for genus-0 surfaces, correcting direction fields and restoring noisy color images. (Received September 23, 2012)

1086-49-1684 **Tiancheng Ouyang*** (ouyang@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602. *New Variational methods on n-body problem of celestial mechanics.*

In this talk, we will introduce our new methods of variational approach combining numerical simulation for N-body problem of celestial mechanics. By using these methods a series of new periodic orbits of N-body problems in \mathbb{R}^3 has been discovered; The numerical simulation and the rigorous analytic proofs of the existence of such orbits and stability are established. (Received September 24, 2012)

1086-49-1741 **Miguel Sama*** (msama@ind.uned.es), ETSI Industriales, Calle Juan del Rosal 12, 28040 Madrid, Spain, **Baasansuren Jadamba** (bxjsma@rit.edu), School of Mathematical Science, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623, and **Akhtar Khan** (aaksma@rit.edu), School of Mathematical Science, Rochester, Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623. *Conical regularization of constrained optimization problems in Banach spaces.*

In this talk, motivated by state-constrained PDE optimal control problems, we deal with an abstract constrained optimization problem in Banach spaces. In this context, by regularization we understand those methods which construct a family of approximate problems which can be solved through Lagrange multiplier rules. This new approach consider a direct regularization of the constraint cone, by replacing the constraint cone by an approximate family of cones. We present several variants and compare them with existing theories. Existence theorems, convergence analysis, and numerical results are presented. (Received September 24, 2012)

1086-49-1872 **Maya Elise Johnson*** (mayaj@math.tamu.edu), 2301 Eastmark Dr., Apt. 340, College Station, TX 77840. *A Mathematical Model of the Effects of Growth and Remodeling on the Artery in a Hypertensive State.*

Hypertension is a medical condition in which the arterial wall is subject to a chronic high blood pressure of at least 140/90 mmHg. Persistent high blood pressure causes the heart to exert more energy to circulate blood through the blood vessels and can lead to life threatening conditions including stroke, heart attack and aortic aneurysm. It becomes very important to develop models to study conditions like hypertension and their effect of the body when considering the need for preventative measures and improved treatments. The current mathematical model addresses the effects that the body's natural tendency towards growth and remodeling has on an artery under various high blood pressures. This is achieved by solving a boundary value problem for the stress experienced by an unloaded residually stressed pressurized artery and then solving a minimization problem to determine how growth and remodeling has to occur in order to bring the body back to a preferred stress state after having been perturbed by hypertensive blood pressures.

(Received September 24, 2012)

1086-49-2080 **Rick Chartrand*** (rickc@lanl.gov). *Image and Video Processing with Nonconvex Splitting Algorithms.* Preliminary report.

In this talk we'll look at applications of alternating direction, method of multipliers (ADMM) algorithms to a selection of problems from image and video analysis. We'll see that better results are obtained by using nonconvex regularization. This can be implemented efficiently, using a nonconvex penalty function that is custom-designed to be minimized by means of a straightforward generalization of soft thresholding. Such efficiency becomes crucial for large-scale applications, particularly those involving video. (Received September 24, 2012)

1086-49-2235 **Danut Arama*** (darama@luc.edu). *Absolute Minimizers for Some L^∞ Optimal Transport Problems.*

In this talk I will introduce a class of problems combining features from optimal transport and minimization of sup norms. I will present two equivalent definitions of solutions followed by existence and duality theorems. Applications of these problems include transportation problems, social behaviour and continuum mechanics. (Received September 25, 2012)

1086-49-2254 **B Jadamba**, Center for Applied and Computational Math., School of Mathematical Sciences, Rochester Institute of Technology, Rochester, NY 14586, **A A Khan*** (aaksma@rit.edu), Center for Applied and Computational Math., School of Mathematical Sciences, Rochester Institute of Technology, Rochester, NY 14586, **M. Sama**, Departamento de Matemática Aplicada, Madrid, Spain, and **B. Winkler**, Center for Applied and Computational Math, School of Mathematical Sciences, Rochester, NY. *A Nonsmooth Convex Optimization Problem in the Inverse Problem of Tumor Identification.*

This talk will focus on the elasticity imaging inverse problem of tumor identification in the human body. To study the inverse problem in an optimization framework, we introduce and analyze two new modified output least-squares (MOLS) objective functionals. We prove that one of the proposed MOLS functionals is convex, circumventing one of the major deficiencies of the existing output least-squares (OLS) functional: its nonconvexity. From the convexity, it follows that the first-order optimality condition expressed as a variational inequality is a necessary and sufficient optimality condition. This is in contrast to OLS, where the corresponding variational inequality is only a necessary optimality condition. Another novelty of this work is in the identification of discontinuous elasticity coefficients in incompressible elasticity using the total variation regularization. Numerical examples for smooth and discontinuous coefficients are given. (Received September 25, 2012)

- 1086-49-2258 **M. Durea** and **R. Strugariu**, "Al. I. Cuza" University, and **Chr. Tammer*** (christiane.tammer@mathematik.uni-halle.de), Institute of Mathematics, Martin-Luther-University of Halle-Wittenberg, Theodor-Lieser-Str. 5, Halle, Germany. *Scalarization in geometric and functional vector optimization revisited.*

The aim of this talk is to provide a survey of some recent results in the field of optimality conditions in vector optimization with geometric and inequality / equality constraints. Moreover, the discussion we initiate leads us to consider new situations which were not previously studied. (Received September 25, 2012)

- 1086-49-2315 **B. Jadamba**, **A. A. Khan**, **M. Sama** and **B. Winkler*** (bcw9368@rit.edu). *Convex Inversion for Parameter Identification in Saddle Point Problems with an Application to the Inverse Problem of Predicting Tumor Location.* Preliminary report.

In this talk we consider an inverse problem of parameter identification in linear incompressible elasticity with an application to tumor identification within the interior of the human body. We introduce and analyze two new modified output least squares (MOLS) objective functionals with the purpose of studying the inverse problem within the context of optimization. We show the convexity of one of these MOLS functionals, overcoming the general deficiency (non-convexity) of the existing output least squares (OLS) method. From this convexity, we also show that the variational inequality expressing the first-order optimality condition is both necessary and sufficient, again in contrast to OLS, whose corresponding expression only provides a necessary optimality condition. Additional related novel work is presented in the recovery of discontinuous elastic coefficients using total variation regularization along with the results of numerical experiments showing the successful identification of both smooth and discontinuous parameters. (Received September 25, 2012)

- 1086-49-2337 **Douglas E. Ward*** (wardde@muohio.edu), Miami University, Department of Mathematics, Oxford, OH 45056. *Generalized Dini Derivatives of the Perturbation Map in Parametric Set-Valued Optimization.* Preliminary report.

In parametric scalar nonlinear programming, estimates are available for the upper and lower Dini directional derivatives of the optimal value function. In this paper, we look at how such estimates can be generalized to a set-valued setting. (Received September 25, 2012)

- 1086-49-2463 **Hayden Schaeffer***, UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095, and **Stanley Osher**, UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095. *Sparse texture patterns and solution to PDE.*

Sparse basis methods are able to capture a wide range of phenomena in an efficient manner. For imaging science, we use a low patch-rank decomposition to model the texture component of an image. In particular, we define a the low rank regularizer which non-locally measures the patches of an image, thus inducing patterns and structured details. Based on experimental results, we demonstrate our method's success on a wide range of textures. Our proposed regularizer is shown to better reconstruct texture for other applications such as denoising, deblurring, sparse reconstruction, pattern regularization, etc. For scientific computing, we solve non-linear and non-local partial differential equations using a sparse basis, thereby capturing the essential dynamics with a small amount of evolving coefficients. As an example, we study the method applied to the vorticity equation (Navier-Stokes) with highly oscillatory forcing terms. (Received September 25, 2012)

- 1086-49-2603 **Marian Bocea*** (mbocea@luc.edu), Loyola University Chicago, Department of Mathematics and Statistics, 1032 W. Sheridan Road, Chicago, IL 60660, and **Mihai Mihailescu** (mmihailes@yahoo.com), University of Craiova, Department of Mathematics, 13 A. I. Cuza St., 200585 Craiova, Romania. *On the continuity of the Luxemburg norm of the gradient in variable exponent Lebesgue spaces.*

We study, via Γ -convergence, the continuity of the Luxemburg norm of the gradient in $L^{p(\cdot)}$ with respect to $p(\cdot)$. The minimum values of closely related "Rayleigh quotient" type functionals are shown to converge to a corresponding quantity associated to the Γ -limit. (Received September 25, 2012)

- 1086-49-2638 **Erika Asano*** (egasano@mail.usf.edu) and **Suzanne Lenhart**. *Optimal resource allocation strategy for the fire ant (*Solenopsis invicta*) over multiple seasons.* Preliminary report.

In monogyn form, each ant colony is a family composed of the offspring of a single queen. Each virgin queen mates, finds a shelter and raises her first brood. Then, the founding queen spends the rest of her life by laying eggs and her sterile workers forage, take care of the queen and broods, and defend their nest from predators. The queen of the fire ant (*Solenopsis invicta*) mates only once at the beginning of her reproductive life. She produces offspring (sterile workers and reproductives) until she uses up the sperm which she initially received. In the field,

typical lifespan of queen is about 6 - 7 years although some may live much longer. A mature colony consists of up to a quarter of a million workers. In our model, monogyne form of the fire ant colony is considered. We formulate and analyze a model using a system of differential equations to study the optimal resource allocation strategies over multiple seasons under different scenarios including seasonal variation in foraging activity and worker mortality rate. (Received September 25, 2012)

1086-49-2658 **Kehinde Rilwan Salau*** (ksalau@asu.edu) and **Eli P Fenichel**. *A bioeconomic perspective on the Endangered Species Act.*

Habitat destruction threatens species existence and has accelerated due to anthropogenic land conversions. In response, the US Congress passed the Endangered Species Act (ESA) to create a set of rules protecting dwindling populations and to set up a platform for recovery. The ESA is explicit about how to characterize a species as threatened or endangered – only biological risks can be evaluated. The act is unclear about what information should be used when determining population delisting. The ESA mandates federal participation in conservation and agencies must curtail socially beneficial activities (e.g. grazing, military training) in order to meet recovery objectives. As funding is limited for agencies, this creates an implicit tradeoff between recovering species and preventing extinction. Reconciliation of recovery goals amidst budget constraints and alternate land-use benefits can be supplemented by economic analysis. This study outlines a bioeconomic approach to framing the recovery problem under the ESA and provides a framework for establishing delisting criteria and a least-cost path to recovery. This approach is also a helpful conceptual tool for evaluating instruments like the ESA on their ability to provide conservation at a socially desired level. (Received September 25, 2012)

1086-49-2703 **Chris Larsen*** (cjlarsen@wpi.edu). *New variational problems for material defect evolution.*

Variational methods have proven very useful for finding certain stable states (global minimizers) for elastic materials with defects such as fracture, damage, and plasticity. However, this stability is sometimes too limiting for studying the time evolution of defects; in fact, in some cases global minimizers do not exist even though local minimizers (in the "right" sense for the evolution) do exist. In this talk, I will describe some variational principles, besides global minimality, for studying these evolutions, as well as some remaining challenges. (Received September 25, 2012)

1086-49-2804 **Julia Eaton*** (jreaton@uw.edu), 1900 Commerce Street, Box 358436, Tacoma, WA 98403, and **James Burke**. *Variational properties of spectral functions with an application to matrix preconditioning.* Preliminary report.

Eigenvalue optimization problems arise in the control of continuous and discrete time dynamical systems. The spectral abscissa (largest real part of an eigenvalue) and the spectral radius (largest eigenvalue in modulus) are examples of functions of eigenvalues, or spectral functions, connected to these optimization problems. In 2001, Burke and Overton showed that the spectral abscissa is subdifferentially regular if and only if all active eigenvalues are nonderogatory. We extend this result to more general class of spectral max functions and explore applications of this result to matrix preconditioning. (Received September 25, 2012)

1086-49-2940 **Amir Moradifam*** (am3937@columbia.edu), Columbia University, New York, NY, and **Adrian Nachman, Alexandru Tamasan** and **Alexandre Timonov**. *Conductivity imaging from minimal interior data.*

We consider the problem of recovering conductivity outside some perfectly conducting inclusions or insulating inclusions from the interior measurement of the magnitude of one current density field $|J|$. We show that the conductivity outside the inclusions, and the shape and position of the inclusions are uniquely determined by the magnitude of the current generated by imposing a given boundary voltage. We will also present a convergent numerical algorithm for the corresponding infinite dimensional L^1 minimization problem. This is a joint work with A. Nachman, A. Tamasan, and A. Timonov. (Received September 26, 2012)

51 ► Geometry

1086-51-328 **Viveka Erlandsson*** (verlandsson@gc.cuny.edu), The Graduate Center, 365 Fifth Avenue, Room 4208, New York, NY 10016. *The Margulis region and screw parabolic elements of bounded type.*

Given a discrete subgroup of the isometries of n -dimensional hyperbolic space there is always a region kept precisely invariant under the stabilizer of a parabolic fixed point, called the Margulis region. While in dimensions 2 and 3 this region is a horoball, it has in general a more complicated shape due to the existence of screw parabolic

elements in higher dimensions. In fact, P. Susskind has shown that in a discrete group acting on hyperbolic 4-space containing a screw parabolic element with irrational rotation, the corresponding Margulis region does not contain a horoball. In this talk we describe the asymptotic behavior of the boundary of the Margulis region when the irrational screw parabolic is of bounded type. As a corollary we show that the region is quasi-isometric to a horoball. Although Y. Kim has shown that two screw parabolic isometries with irrational rotation are not quasi-isometric, this corollary implies that their corresponding Margulis regions (in the bounded type case) are quasi-isometric. (Received August 21, 2012)

1086-51-361 **Anja Bankovic*** (bankovi1@illinois.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Horowitz-Randol phenomenon for q -differential metrics.*

In this talk we'll discuss length functions on a variety of spaces of metrics on a genus $g > 1$ surface. In particular, we will examine a phenomenon first observed by Horowitz and Randol that there are arbitrary large sets of homotopy classes of closed curves on a surface whose lengths are equal in every hyperbolic metric. We will introduce a family of flat metrics and discuss this phenomenon on the subfamily of flat metrics coming from q -differentials. (Received August 30, 2012)

1086-51-377 **J Mealy*** (jmealy@austincollege.edu), 900 North Grand Avenue, Suite 61560, Sherman, TX 75090. *New Asymptotica in Snell Geometries.*

Further results in the category, Snell Geometry. (See Snell Geometry abstracts from MathFests 2008 – 2011, Joint Meeting 2011.) First, a summary view of what the general category of Snell Geometry entails will be given, with a brief mention of some earlier results. Then the methodology of the category will be discussed, focusing in particular on how it contrasts with the differentiable approach. Then, details of a few new systems will be given, including some whose underlying parameter spaces are spheres; in particular, we discuss the construction of specific geometries that contain n -ly asymptotic n -gons (that is, whose sides are infinite) with (strictly) positive asymptotic angle sum values. (Received August 27, 2012)

1086-51-424 **Diana Davis*** (diana@math.brown.edu). *Shearing, twisting and geodesics on polygon surfaces.*

We create a surface by identifying opposite parallel edges of a polygon or polygons, and then we consider a twisting automorphism of the surface. The question is, given a geodesic path on the original surface, what happens to the path when we twist the surface? What happens to the associated “cutting sequence” of edges that the trajectory crosses? We will discuss results for various Veech surfaces, including regular polygons and Bouw-Moller surfaces. (Received August 31, 2012)

1086-51-467 **Babak Modami*** (babak.modami@yale.edu), Mathematics Department, Yale University, 442 Dunham Lab., 10 Hillhouse Ave., New Haven, CT 06511. *Prescribing the behavior of Weil-Petersson geodesics.*

Weil-Petersson (WP) metric is an incomplete Riemannian metric on the moduli space of Riemann surfaces with negative sectional curvatures. The sectional curvatures are not bounded away from 0 and $-\infty$. Due to these features most of the standard techniques would not apply to study the global geometry and dynamics of WP metric.

In this talk we will present some partial results about prescribing the behavior of WP geodesics and parametrization of their asymptotic classes. For this purpose we would use a notion of ending lamination for WP geodesic rays and the assigned subsurface coefficients to any pair of them. Examples of WP geodesics staying away from a compact set and diverging rays would be discussed.

These results would be considered as an analogue of the coding of geodesics on the modular surface in terms of continued fraction expansions. (Received September 03, 2012)

1086-51-661 **Qionglin Li*** (q14@rice.edu). *Teichmuller Space Is Totally Geodesic In Goldman Space.* Preliminary report.

In this talk, we construct a new Riemannian metric on Goldman space, the deformation space of convex real projective structures on a compact genus $g (g > 1)$ surface, and then prove the new metric and the metric of Darvishzadeh and Goldman both restrict to be Weil-Petersson metric on Teichmuller space. Moreover, Teichmuller space endowed with Weil-Petersson metric is totally geodesic in Goldman space, as a Riemannian manifold. Finally, we consider a circle action on Goldman space and prove it preserves the metric. (Received September 10, 2012)

- 1086-51-946 **John Jacob Zanazzi*** (jz57@nau.edu), 400 E. McConnel Dr. #61, Flagstaff, AZ 86001.
A Proof Related to the Projections of Polyhedra.

In 1959, Klee proved that an n -dimensional convex body K is polyhedral if all of its j -projections are polyhedral. In three dimensional space, this statement may be rephrased as follows: If K is a compact convex set in \mathbb{R}^3 such that all of its projections into \mathbb{R}^2 are convex polygons, then K is a convex polyhedron. In this paper, a new proof of the three dimensional case is presented. (Received September 16, 2012)

- 1086-51-1147 **Andrei Gabrielov***, agabriel@math.purdue.edu, and **Saugata Basu and Nicolai Vorobjov**. *Semi-Monotone Sets, Monotone Maps, and Triangulation of Monotone Families*. Preliminary report.

Let $S(t)$, defined for small $t > 0$, be a monotone family (i.e., $S(t) \subset S(u)$ for $t > u > 0$) of compact subsets of a compact set $K \subset \mathbb{R}^n$. Both $S(t)$ and K are assumed to be “tame” (e.g., real semialgebraic). The following problem emerges from a conjecture formulated by Gabrielov and Vorobjov (2009) in connection with their work on approximation of a tame set by homotopy equivalent compact sets: Construct a triangulation of K so that restriction of $S(t)$ to each open simplex is equivalent to a “standard” family. The explicit list of $2^n + 1$ standard families is based on lex-monotone Boolean functions in n Boolean variables. A second conjecture claims that K admits a cylindrical cell decomposition into regular cells, such that restriction of $S(t)$ to each open k -cell C is either empty or a regular k -cell, and its boundary in C is either empty or a regular $(k - 1)$ -cell. To prove these conjectures, Basu, Gabrielov and Vorobjov introduced semi-monotone sets, a generalization of convex sets, and monotone maps, a multivariate generalization of univariate monotone functions. Recent progress towards the proof of the above conjectures will be reported. (Received September 19, 2012)

- 1086-51-1204 **Emily Dinan*** (edinan@fordham.edu), 3076 Sunny Ayre Drive, Lansdale, PA 19446, **Alice Nadeau** (nadeaua@grinnell.edu), 240 Ivanhoe Road, Waterloo, IA 50701, and **Issac Odegard** (issac.odegard@gmail.com), 625 N 43rd St Apt 208, Grand Forks, ND 58203.
On the Folding of L-Shapes into Polyhedra.

Recent work in computational geometry has begun to address the question: Can a given convex polyhedron be unfolded into a simple polygon and then refolded into any other convex polyhedron? One facet of this question investigates the space of polyhedra that can be realized from folding a given polygon. While the folding of convex polygons is fairly well understood, there are still many open questions regarding the foldings of non-convex polygons, and current methods for determining their polyhedral realizations are computationally inefficient. We analyze these realizations and their volumes derived for the polygonal family of ‘L-shapes,’ parallelograms with a parallel copy removed from a corner. This family includes the special case of the rectangle which has been previously studied. We study the family of polyhedra that unfold to a common L-shape and provide developments in the topics of maximal volume polyhedron, edge relocation, diagonal flipping, and topological space. (Received September 20, 2012)

- 1086-51-1785 **Yahya Almalki*** (yaa09d@my.fsu.edu), Department of Mathematics, Florida State University, Tallahassee, FL 32304. *Representations Varieties and Teichmüller Spaces of non-Orientable Surfaces.*

We study some basic properties of the Teichmüller Spaces of non-Orientable Klein Surfaces. We study the methods of Seppälä-Sorvali using multipliers of Möbius transformations. To extend their work to the non-orientable case, we study the methods of representation and character varieties of the fundamental groups of these surfaces. (Received September 24, 2012)

- 1086-51-1850 **Aaron D Valdivia*** (aaron.david.valdivia@gmail.com), 756 Vistabula St, Lakeland, FL 33801. *Asymptotically small pseudo-Anosov sequences.*

We will describe a generalization of examples of pseudo-Anosov mapping classes with asymptotically small dilatation. These examples will give answers to asymptotic questions about least dilatation and least translation length in the curve complex. (Received September 24, 2012)

- 1086-51-1926 **Emmy Murphy*** (e_murphy@mit.edu), Massachusetts Institute of Technology, Building 2, Room 236, 77 Massachusetts Avenue, Cambridge, MA 02139. *Lagrangian caps in \mathbb{C}^2 .*

Thinking of $S^3 \subseteq \mathbb{C}^2$, a smooth knot K is called Legendrian if the vector field $i \frac{dK}{dt}$ is tangent to S^3 everywhere. We study how exact Lagrangians in \mathbb{C}^2 interact with Legendrian knots in S^3 . Because there is no symplectomorphism of $\mathbb{C}^2 \setminus \{0\}$ exchanging the inside and outside, an exact Lagrangian surface in $B^4 \subseteq \mathbb{C}^2$ with boundary K will have very different properties than an exact Lagrangian in $\mathbb{C}^2 \setminus B^4$ with boundary K . We call the former a *Lagrangian filling*, and the latter a *Lagrangian cap*. We discuss several results on the interactions between

symplectic topology and knot theory, focusing on a recent theorem which states that any Legendrian knot admits a Lagrangian cap after sufficient stabilization. (Received September 24, 2012)

1086-51-2054 **Jeroen Schillewaert*** (jschillewaert@gmail.com), 7942 Avenida Navidad #104, San Diego, CA 92122. *A combinatorial characterization of Severi varieties over arbitrary fields (joint work with H. Van Maldeghem).*

The Freudenthal-Tits magic square (FTMS), may be loosely described as the octonionic construction by means of composition algebras of the exceptional Lie groups and their associated algebras, except for G_2 , which is the automorphism group of the octonions.

	K	L	H	O
K	A_1	A_2	C_3	F_4
L	A_2	$A_2 \times A_2$	A_5	E_6
H	C_3	A_5	D_6	E_7
O	F_4	E_6	E_7	E_8

The geometries corresponding to the second row of the split version of the FTMS (over any field) are Severi varieties, which are central objects in algebraic geometry and algebraic group theory.

In this talk we characterize all these varieties in a simple and uniform way. In particular, this includes a characterization of the standard module for groups of type E_6 over any field. It is remarkable that this intricate geometric structure allows to be caught by a rather simple and short list of axioms. (Received September 24, 2012)

1086-51-2461 **Whan Ghang** and **Zane Martin*** (zan3rm@gmail.com), 1347 Paresky Center, Williamstown, MA 01267, and **Steven Waruhiu**. *Perimeter-minimizing Planar Tilings by Pentagons.*

Hales proved that regular hexagons provide the least-perimeter way to partition the plane into unit areas. What are the best tilings by pentagons? Could it possibly help to mix in some non-convex pentagons? (Received September 25, 2012)

1086-51-2785 **Robert D. Knight*** (puzzled40@yahoo.com), 101 University Ave, Chillicothe, OH 45601. *Desargues' Theorem in Laguerre Planes.*

An Ovoidal Laguerre plane can be defined as the set of points of a cylinder over an oval in an affine 3-space, together with the set of "circles" resulting from intersecting this cylinder with planes not parallel to the generators of the cylinder. The points are traditionally referred to as "spears" and the circles as "cycles". Using lattice theory, Jeff Kahn proved in 1980 that a Laguerre plane is ovoidal iff it satisfies a set of conditions called the Full Bundle Theorem. The spears and cycles of a general Laguerre plane can be represented by affine planes and points, respectively, of a near-linear space. In this space the Full Bundle Theorem takes a form analogous to the Veblen-Young Axiom for projective spaces. We provide a direct, synthetic proof that a form of Desargues' Theorem within this near-linear space holds iff the Full Bundle Theorem holds. (Received September 25, 2012)

52 ► Convex and discrete geometry

1086-52-204 **Catherine Stenson*** (stenson@juniata.edu), Department of Mathematics, Juniata College, 1700 Moore St., Huntingdon, PA 16652. *A Polytopal Interpretation of the Banzhaf Power Index.* Preliminary report.

In a weighted voting system, each player has a certain number of votes and casts them all for or against a proposal. The proposal passes if the total number of votes exceeds some quota. A player's influence is measured by the Banzhaf Power Index, which counts the ways in which a player's vote can be critical to passing a proposal. Two weighted voting systems are equivalent if they have exactly the same winning coalitions, which means they correspond to the same region in a particular hyperplane arrangement. We show that the coordinates of the vertices of the polytope dual to this hyperplane arrangement have a nice connection to the Banzhaf Power Index. We also give a geometric interpretation of changes in the quota. (Received August 07, 2012)

1086-52-376 **Ellen Veomett*** (erv2@stmarys-ca.edu) and **A. J. Radcliffe**. *Vertex Isoperimetric Inequalities for a Family of Graphs on \mathbb{Z}^k .*

We consider the family of graphs whose vertex set is \mathbb{Z}^k where two vertices are connected by an edge when their ℓ_∞ -distance is 1. We prove the optimal vertex isoperimetric inequality for this family of graphs. That is, given

a positive integer n , we find a set $A \subset \mathbb{Z}^k$ of size n such that the number of vertices who share an edge with some vertex in A is minimized. These sets of minimal boundary are nested, and the proof uses the technique of compression.

We also show a method of calculating the vertex boundary for certain subsets in this family of graphs. This calculation and the isoperimetric inequality allow us to indirectly find the sets which minimize the function calculating the boundary. (Received August 27, 2012)

1086-52-559 **Igor Pak***, Department of Mathematics, UCLA, Los Angeles, CA 90095. *Tiling with rectangles.*

I will discuss complexity of tileability of finite simply connected regions in the plane with rectangles. Joint work with Jed Yang. (Received September 07, 2012)

1086-52-560 **Igor Pak*** (pak@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095. *Triangulation problems.* Preliminary report.

I will discuss several problems related to triangulations of polyhedra, both geometric, combinatorial and topological. I will give a brief survey of what has been done, and present some open problems. (Received September 07, 2012)

1086-52-561 **Igor Pak***, Department of Mathematics, UCLA, Los Angeles, CA 90095. *Realization of polyhedral complexes.*

I will discuss the problems of realization of polyhedral complexes in 3 and higher dimensions, related to generalizations of Fary, Steinitz and Tutte theorems. The irrationality phenomenon is also discussed. Joint work with Stedman Wilson. (Received September 07, 2012)

1086-52-755 **Jesus De Loera*** (deloera@math.ucdavis.edu), Dept. of Mathematics, University of California, Davis, CA 95616. *Top Ehrhart coefficients of integer partition problems.* Preliminary report.

Top Ehrhart coefficients of integer partition problems

For a given sequence $\mathbf{a} = [\alpha_1, \alpha_2, \dots, \alpha_N]$ of N positive integers, we consider the parametric integer partition problem $\alpha_1 x_1 + \alpha_2 x_2 + \dots + \alpha_N x_N = t$, where right-hand side t is a varying non-negative integer. It is well-known that the number $E_{\mathbf{a}}(t)$ of solutions in non-negative integers x_i is given by a quasi-polynomial function of t of degree N , the so called Ehrhart quasipolynomial function, very prominent in algebraic combinatorics. Computing the entire function $E_{\mathbf{a}}(t)$ is known to be #P-hard, and even deciding when the function vanishes is NP-hard. I present a new polynomial time algorithm that for a fixed number k , we computes the highest $k+1$ coefficients of the quasi-polynomial $E_{\mathbf{a}}(t)$ represented as step polynomials of t . This is a nice application of a natural poset on the set of possible gcd's of subsets of numbers in \mathbf{a} . To conclude, I present some applications to understanding the periodicity of $E_{\mathbf{a}}(t)$ for some classical partition problems. This is joint work with **V. Baldoni, N. Berline, M. Koepe, and M. Vergne**. (Received September 12, 2012)

1086-52-1115 **Jonathan E Beagley*** (jbeagley@gmu.edu), Department of Mathematical Sciences, 4400 University Drive, MS 3F2, Fairfax, VA 22030, and **Walter Morris** (wmorris@gmu.edu), Department of Mathematical Sciences, 4400 University Drive, MS 3F2, Fairfax, VA 22030. *An Esther Klein Type Coloring Theorem.*

In 1935, Paul Erdős and George Szekeres introduced a problem of planar point sets in general position (no three on a line): find the least integer $N(n)$ such that every planar point set of $N(n)$ points in general position contains n points that are convexly independent (form the vertex set of a convex n -gon). We introduce a related problem on the chromatic number of a graph of Morris, and show it has a finite upper bound. This graph on the copoints of planar point sets can be extended to abstract convex geometries. The cliques of this graph correspond to convexly independent sets, and the chromatic number is related to the order dimension of the lattice of convex sets. (Received September 19, 2012)

1086-52-1161 **Gregory Berkolaiko*** (berko@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *Nodal count of eigenfunctions as index of instability.*

Courant's celebrated nodal bound asserts that the zero curves of the n -th eigenfunction of the Laplace operator on a compact domain partition the domain into at most n parts (which are called "nodal domains"). However, the actual number of nodal domains is usually well below the Courant's bound.

It recently transpired that the difference between the bound and the actual value can be interpreted as an index of instability of a certain energy functional with respect to suitably chosen perturbations. The results

concerning this phenomenon fall in two classes: (1) stability of the nodal partitions with respect to a perturbation of the partition boundaries and (2) stability of the eigenvalue with respect to a perturbation by magnetic field. We will discuss examples of the available results and the connections among them.

Based on joint work with R. Band, P.Kuchment and U.Smilansky, H. Raz and T. Weyand (Received September 19, 2012)

1086-52-1402 **Jeremiah D Bartz*** (jbartz@uoregon.edu). *New Examples of Multinets in \mathbb{P}^2 and \mathbb{P}^3 .* Preliminary report.

In the study of resonance varieties, one uses specific configurations of points and lines in \mathbb{P}^2 called nets and multinets. Very few examples of multinets are known. Furthermore, there is a conjecture that every multinet is a degeneration of a net. In this work, numerous new examples of multinets are exhibited, each which is a degeneration of a net. (Received September 21, 2012)

1086-52-1464 **Issam I. Safa*** (issam.safa@gmail.com), Columbus, OH 43221. *Features Reconstruction Gets Help From Unlikely Sources: Graph Laplacian and Reeb Graph.*

Reconstructing sharp features from a set of discrete points sampled from a hidden surface is a fundamental problem in geometric modeling. The task becomes challenging in the presence of "singularities" in the surface such as boundaries and non-manifold regions. The reconstruction process can be broken into two steps: first identifying the feature points, and second, reconstructing the feature lines using the identified points. We achieve this by recruiting the help of two unlikely sources: the graph Laplacian and the Reeb graph. In this talk, we will discuss recent results on the behavior of the graph Laplacian in the vicinity of a certain class of singularities, how we can use the Laplacian to identify sample points near feature lines, and how we can use the Reeb graph to reconstruct the feature lines themselves. (Received September 22, 2012)

1086-52-1513 **Alexey Glazyrin*** (alexey.glazyrin@utb.edu), 80 Fort Brown, University of Texas at Brownsville, Department of Mathematics, Brownsville, TX 78520. *On simplicial dissections of simplotopes.* Preliminary report.

The talk is devoted to triangulations and simplicial dissections of polytopes without additional vertices. In 2009 we proved the theorem about volume invariants of simplicial dissections of prismoids. Applying this theorem we made a general construction of weighted volumes and, by choosing the proper matrix of parameters, proved the new asymptotic lower bound for the number of simplices in simplicial dissections of n -cubes: the number of simplices in such dissections is at least $(n+1)^{\frac{n-1}{2}}$.

In this talk we are going to generalize the theorem about volume invariants and use it for constructing weighted volumes of simplotopes, i.e. direct sums of simplices. This construction allows us to find new lower bounds for simplicial dissections of simplotopes. (Received September 23, 2012)

1086-52-1602 **Kathryn Leonard*** (kathryn.leonard@csuci.edu). *Two-dimensional shape analysis: Case studies from industry.*

We present a few projects in geometric two-dimensional shape analysis arising from specific needs of collaborators at software and robotics firms and U.S. government agencies. After an overview of the scientific questions involved, we will discuss the mutual benefits to industry and academia of these kinds of intellectually cross-cultural collaborations. (Received September 23, 2012)

1086-52-1661 **Daoji Huang*** (huangd@carleton.edu), 300 N College St, Northfield, MN 55057. *Discrete Folds of Tree Spaces.*

A classical problem in computational biology is the construction of a phylogenetic tree from a sequence alignment of n species. The work by Billera, Holmes, and Vogtmann (2001) provides a construction of a space BHV_n of such metric trees, which is shown to have a CAT(0)-structure, enabling the computation of geodesics and centroids. An alternate phylogenetic tree space introduced by Kim (2000), known as the "space of phylogenetic oranges", is a more general tree space that captures forests rather than trees. We study the connection between these two tree spaces in terms of combinatorial moves on trees induced by infinite edge, producing a "discrete path tree space" in the process. The image of a chamber can be described in terms of a product of cubes and simplices that allow straightforward descriptions of the collapsing map. (Received September 23, 2012)

1086-52-2058 **Md. Jawaherul Alam*** (mjalalam@cs.arizona.edu), 3528 East 2nd Street # 74, Tucson, AZ 85716, and **James R. Ashe** (jashe@math.utk.edu), **Michael Dobbins** (athmwiji@gmail.com), **Muriel Dulieu** (mdulieu@gmail.com) and **Justin Iwerks** (jiwerks@gmail.com). *Tetrahedron Contact Graphs*. Preliminary report.

We explore a problem posed by Joseph O'Rourke which asks to characterize tetrahedron contact graphs, i.e. the class of undirected simple graphs that can be realized as arrangements of interior-disjoint intersections of tetrahedra. More precisely, in such a representation of a graph G , the vertices of G are represented by interior-disjoint tetrahedra and each edge of G corresponds to a shared boundary between the two corresponding tetrahedra such that for each edge one can specify a unique point on the common boundary. We studied this problem for different variants where we considered contacts between only regular tetrahedra, or general (possibly) irregular tetrahedra; along with a more restricted contact model that requires vertex-to-vertex touching for each edge. We give some preliminary results in different variants of the problem. For example, using irregular tetrahedra in the general contact model, we can realize any complete graph K_n for $n \leq 10$ as well as any complete tripartite graph. For regular tetrahedra in the vertex-to-vertex model we demonstrate that K_n can be realized for $n \leq 4$, but K_5 is not realizable. (Received September 24, 2012)

1086-52-2127 **Karoly Bezdek*** (bezdek@math.ucalgary.ca), 2500 University Drive NW, Department of Mathematics and Statistics, University of Calgary, Calgary, Alberta T3G5Z3, Canada. *On Rigidity of Ball-Polyhedra in Euclidean 3-Space*.

The rigidity theorems of Cauchy(1813), Alexandrov (1950), and Stoker(1968) are classical results in the theory of convex polyhedra. We prove analogues of them for (standard as well as normal) ball-polyhedra. Here, a ball-polyhedron means an intersection of finitely many congruent balls in Euclidean 3-space. (Received September 24, 2012)

1086-52-2286 **Dominic Spadacene*** (domspad@umich.edu), 6003 Woodview Pass, Midland, MI 48642, and **Craig Corsi**, **Satyan Devadoss** and **Daoji Huang**. *Polyhedral Coverings of Tree Space*.

A classical problem in computational biology is the construction of a phylogenetic tree from a sequence alignment of n species. The work by Billera, Holmes, and Vogtmann (2001) provides a construction of a space T_n of such trees, which was shown to have a CAT(0)-structure, enabling the computation of geodesics and centroids. Due to its conical structure, the combinatorial characteristics are encoded in its cross-section L_n , a simplicial complex, which from an operadic viewpoint corresponds to fully-grown trees. We provide a novel construction of L_n in the language of the associahedron and the permutohedron, famous classical polytopes that encapsulate algebraic information. These polytopes themselves appear in numerous contexts, ranging from root systems and knot theory to Floer homology and moduli spaces of curves. We prove that L_n is covered by $n!$ associahedra, with the discrete fiber over this map keeping track of the planarity of the tree structure. Moreover, permutohedra are shown to be embedded in L_n , each corresponding to a caterpillar tree. Finally, we reinterpret the topological results regarding L_n of Robinson and Whitehouse (1996), demonstrating that each permutohedron completely captures the homotopy structure of L_n as a wedge of spheres. (Received September 25, 2012)

1086-52-2291 **Justin Malestein*** (justinmalestein@gmail.com), Einstein Institute of Mathematics, Edmond J. Safra Campus, Givat Ram, Hebrew University of Jerusalem, 91904 Jerusalem, Israel, and **Louis Theran**. *Generic rigidity for frameworks with symmetry*.

In this talk, I will discuss characterizations of generically rigid frameworks with various symmetries in dimension 2. In particular, I will present theorems about frameworks with “forced” symmetry. The main focus will be the “degree of freedom” heuristic for arriving at the right conditions. This is joint work with Louis Theran. (Received September 25, 2012)

1086-52-2347 **Sergiy V. Borodachov** and **Douglas P Hardin*** (doug.hardin@vanderbilt.edu), Department of Mathematics, Vanderbilt University, Nashville, TN 37240, and **Edward B Saff**. *Asymptotics of discrete minimum energy problems*.

The problem of finding configurations of points that are “optimally-distributed” on a compact set appears in a number of guises including best-packing problems, coding theory, geometrical modeling, statistical sampling, and mesh-generation.

We consider ‘ground state’ point configurations $\{x_i\}_{i=1}^N$ on a set $A \subset \mathbb{R}^n$ that minimize a weighted energy functional of the form

$$\sum_{i \neq j} \frac{w(x_i, x_j)}{\|x_i - x_j\|^s},$$

for a given ‘weight’ function w on $A \times A$ and a parameter $s > 0$. We review classical and recent results concerning asymptotic geometrical properties of such configurations as $N \rightarrow \infty$ and discuss low-complexity methods for computing near-optimal configurations. (Received September 25, 2012)

1086-52-2857 **John Chiarelli** (jlc625@nyu.edu), **Robert Connelly** (rc46@cornell.edu) and **Lisa Piccirillo*** (piccirli@bc.edu). *On Unit Triangle and Square Tilings in \mathbb{R}^2 .*

The tiling completion problem (Goodman-Strauss, 2000) questions the decideability the following: Given some proset of tiles, does some edge to edge combination of them tile a given boundary?

We prove that in \mathbb{R}^2 for oriented unit triangle and square tiles the problem is decideable, and give necessary and sufficient criteria.

For unoriented unit triangle and square tiles, we prove this problem is decideable for a convex boundary in \mathbb{R}^2 and give criteria. Additionally we provide an invariant for determining the canonical proset of unoriented tiles for any tileable boundary (Received September 25, 2012)

53 ► Differential geometry

1086-53-310 **Yunhui Wu*** (yw22@rice.edu), MS-136, P.O. Box 1892, Houston, TX 77251-1. *Iteration of mapping classes and limits of Weil-Petersson geodesics.*

Let $S = S_{g,n}$ be a surface of negative Euler-characteristic, of genus g , and with n punctures. Let $Teich(S)$ be the Teichmüller space endowed with the Weil-Petersson metric and $Mod(S)$ be the mapping class group of S . Fix $X, Y \in Teich(S)$. In this paper, we show that for any $\phi \in Mod(S)$, there exists a positive integer k depending on ϕ such that the sequence of the directions of geodesics connecting X and $\phi^{kn} \circ Y$ is convergent in the visual sphere of X . Moreover we will give a geometric description for the geodesic whose direction is the limit. (Received August 18, 2012)

1086-53-570 **Christopher R. Godbout*** (cgodbout@ursinus.edu), Collegeville, PA 19426. *Chern-Simons classes and the Ricci flow on 3-manifolds.*

In 1974, S.-S. Chern and J. Simons published a paper where they defined a new type of characteristic class - one that depends not just on the topology of a manifold but also on the geometry. The goal of this paper is to investigate what kinds of geometric information is contained in these classes by studying their behavior under the Ricci flow. In particular, it is shown that the Chern-Simons class corresponding to the first Pontryagin class is invariant under the Ricci flow on the warped products $S^2 \times_f S^1$ and $S^1 \times_f S^2$ but that this class is not invariant under the Ricci flow on a generalized Berger sphere. (Received September 07, 2012)

1086-53-651 **Guoyi Xu*** (guoyixu@math.uci.edu), 340 Rowland Hall, University of California, Irvine, Irvine, CA 92697. *Short time asymptotic behavior of the logarithm of heat kernel.*

Let (M^n, g) be a compact Riemannian manifold, $H(x, y, t)$ is the heat kernel on M^n , and $H = (4\pi t)^{-\frac{n}{2}} e^{-f}$. Define $\bar{f} = f - \int_{M^n} fH$, in Perelman’s well-known paper about Ricci flow entropy, as a special case of his general claim, $[(\frac{\partial}{\partial t} + \Delta)\bar{f} + \frac{\bar{f}}{t}](x, y, t)$ is of order $O(1)$ for (x, t) near $(y, 0)$. Motivated by this static metric case, we studied the asymptotic behavior of $\int_{M^n} fH$ and $\frac{\partial}{\partial t}(\int_{M^n} fH)$ as $t \searrow 0$, and got the asymptotic formulas. (Received September 10, 2012)

1086-53-710 **Andrew M Sanders*** (sanderandy@gmail.com), University of Maryland, College Park, Mathematics Dept., College Park, MD 20742. *Domains of discontinuity of almost-Fuchsian groups.*

An almost-Fuchsian group $\Gamma < \text{Isom}^+(\mathbb{H}^3)$ is a quasi-Fuchsian group which preserves an embedded minimal disk in hyperbolic 3-space such that the quotient of this disk is a closed surface all of whose principal curvatures lie in the interval $(-1, 1)$. The hyperbolic gauss map from the minimal disk defines a diffeomorphism onto each component of the domain of discontinuity of Γ . We will explain how a study of the gauss map imposes constraints on the structure of the domain of discontinuity. In particular, we will explain how this structure can be used to show that no geometric limit of almost-Fuchsian groups can be doubly degenerate. (Received September 11, 2012)

1086-53-897 **Michael Eastwood*** (meastwoo@member.ams.org). *Bernstein-Gelfand-Gelfand Complexes.* The equations of elasticity are closely related to the equations of Riemannian geometry in three dimensions. These equations enjoy extra symmetries leading to a BGG (Bernstein-Gelfand-Gelfand) complex in the linearised theory. I shall explain how this works and sketch the scope of the BGG machinery (since perhaps there are other applications unknown to the speaker (who works in pure differential geometry)). The talk will concentrate

on examples (and suppress the representation theory that lurks in the background). (Received September 15, 2012)

1086-53-951 **Ken'ichi Sekiya*** (kenichisekiya.g@gmail.com). *Generalized almost contact structures and generalized Sasakian structures*. Preliminary report.

We introduce generalized almost contact structures which admit the B -field transformations on odd dimensional manifolds. We provide definition of generalized Sasakian structures from the view point of the generalized almost contact structures. We obtain a generalized Sasakian structure on a non-compact manifold which does not arise as a pair of ordinary Sasakian structures. However we show that a generalized Sasakian structure on compact 3-dimensional manifold is equivalent to a pair of Sasakian structures with the same metric. (Received September 17, 2012)

1086-53-985 **Abbas Bahri** and **Ali Maalaoui*** (ali.maalaoui@gmail.com), Rutgers University, Hill Center for, the Mathematical Sciences, 110 Frelinghuysen Rd, Piscataway, NJ 08854, and **Vittorio Martino**. *The topology of a subspace of the Legendrian curves in a closed contact 3-manifold*. Preliminary report.

In this talk we are going to prove a theorem that can be seen as related Smale's theorem about Legendrian loops, only that the framework is different and the space of Legendrian loops is replaced by a smaller space \mathcal{C}_β , that appears to be convenient in contact form geometry. (Received September 17, 2012)

1086-53-1002 **Wyatt Howard*** (whoward@ucsc.edu), University of California Santa Cruz, Department of Mathematics, 4111 McHenry, Santa Cruz, CA 95064, and **Alex Castro** (alex.castro@mat.puc-rio.br), Departamento de Matemática, Rua Marquês de São Vicente, 225-Edifício, Cardeal Leme, sala 862, Rio de Janeiro, 22453-900, Brazil. *A Monster Tower Approach to Goursat Multi-Flags*.

In this talk I will consider the problem of classifying the orbits within a tower of fibrations with \mathbb{P}^2 -fibers that generalize the Monster Tower due to Montgomery and Zhitomirskii. The action on the tower is given by prolongations of diffeomorphism germs of 3-space called symmetries. Montgomery and Zhitomirskii have pointed out that the classification problem of points within the Monster Tower up to symmetry is equivalent to the classification problem for Goursat 2-flags. Goursat 2-flags arise in the study of dynamical systems. More specifically, the n -rigid bar system as well as F. Jean's car with n -trailers are known examples. I will present the first steps towards the problem of classifying Goursat 2-flags of small length. In short, I will outline the classification of the orbits within the first four levels of the Monster Tower. (Received September 17, 2012)

1086-53-1061 **Mark Gross*** (mgross@math.ucsd.edu), **Valentino Tosatti** (tosatti@math.northwestern.edu) and **Yuguang Zhang** (yuguangzhang76@yahoo.com). *Recent results on Gromov-Hausdorff limits of Calabi-Yau manifolds*.

I will talk about recent work in understanding Gromov-Hausdorff limits of abelian variety fibred Calabi-Yau manifolds. Given an abelian variety fibration $f : M \rightarrow N$ with M a Calabi-Yau manifold, one considers a family of Ricci-flat Kähler metrics converging to a wall of the Kähler cone of M corresponding to the fibration f , i.e., one considers a family of Kähler classes $f^*[\omega_0] + t[\omega]$ where ω_0 is a Kähler form on N and ω a Kähler form on M . For each $t \neq 0$, we obtain a Ricci-flat metric ω_t in this Kähler class. As $t \rightarrow 0$, ω_t degenerates, and we examine the Gromov-Hausdorff limit, showing we obtain collapsing to a metric space closely related to N (possibly homeomorphic to N). (Received September 18, 2012)

1086-53-1242 **Sergey Grigorian*** (sgrigorian@scgp.stonybrook.edu), Stony Brook University, Stony Brook, NY 11794-3636. *Short time behaviour of a modified Laplacian coflow of G_2 -structures*.

We modify the Laplacian coflow of co-closed G_2 -structures - $\frac{d}{dt}\psi = \Delta\psi$ where ψ is the closed dual 4-form of a G_2 -structure φ . The modified flow is now parabolic in the direction of closed forms up to diffeomorphisms. We then prove short time existence and uniqueness of solutions to the modified flow. (Received September 20, 2012)

1086-53-1254 **David E Betounes*** (betounes_d@utpb.edu), 4901 E. University Blvd, Odessa, TX 79762. *The Geometry of Space-Time-Matter*.

We formulate a global, differential geometric structure for the space-time-matter theory introduced by Wesson and coworkers. In addition to giving a coordinate-free, intrinsic approach to the theory, we extend the discussion from 5-dimensions to arbitrary dimensions.

Our model for space-time-matter is a Ricci flat, semi-Riemannian manifold (E, \bar{g}) , where E is a fiber bundle over M (the spacetime) and \bar{g} is a Kaluza-Klein metric on E . Each space-time-matter manifold (E, \bar{g}) generates spacetimes (M, \tilde{g}) , one for each embedding of M in E , with stress-energy tensor for M determined by the geometry of E and the nature of the embedding. (Received September 20, 2012)

1086-53-1289 **Yongsheng Zhang*** (yzhang@math.sunysb.edu), Department of Mathematics, Stony Brook University, Stony Brook, NY 11794. *Gluing Techniques in Calibrated Geometry.*

In this talk, we will describe some ideas recently developed to construct metrics with nice properties for various cases from the point of view of calibrated geometry. Other relevant questions may be briefly mentioned if time permits. (Received September 20, 2012)

1086-53-1353 **Michael Bailey*** (bailey@cirget.ca), CIRGET, Université du Québec à Montréal, PO Box 8888, Succursale centre-ville, Montréal, QC H3C 3P8, Canada. *Aspects of type change in generalized complex geometry.*

Generalized complex geometry is a generalization of both complex and symplectic geometry, which has applications in string theory and mirror symmetry. We will give a definition and some examples, and then present a local classification in terms of holomorphic Poisson structures. One interesting aspect of the theory is the phenomenon of type change, whereby the number of complex vs. symplectic dimensions may vary over a generalized complex manifold. We will present new results about this phenomenon; in particular, the complex locus admits a canonical complex analytic scheme structure. (Received September 21, 2012)

1086-53-1375 **Gueo Grantcharov*** (grantchg@fiiu.edu) and **Misha Verbitsky**. *Calibrations in hyperkaehler geometry.*

We describe a family of calibrations arising naturally on a hyperkähler manifold M . These calibrations calibrate the holomorphic Lagrangian, holomorphic isotropic and holomorphic coisotropic subvarieties. When M is an HKT (hyperkähler with torsion) manifold with holonomy $SL(n, \mathbb{H})$, we construct another family of calibrations Φ_i , which calibrates holomorphic Lagrangian and holomorphic coisotropic subvarieties. The calibrations Φ_i are (generally speaking) not parallel with respect to any torsion-free connection on M . (Received September 21, 2012)

1086-53-1454 **Tommy Murphy*** (tmurphy@ulb.ac.be). *Submanifolds and Riemannian foliations of symmetric spaces.*

In submanifold theory one aims to classify submanifolds of a given manifold satisfying local geometric conditions. In contrast Riemannian foliations are global objects, but for Riemannian symmetric spaces there is a notable interplay between these two concepts. I will outline something of this relationship, focusing mostly on spheres and complex projective space for simplicity. In particular, I will answer a question of Alfred Gray classifying the complex submanifolds of $\mathbb{C}P^n$ arising as the exceptional leaves of a Riemannian foliation of maximal dimension. Complex Riemannian foliations of open subsets of Hermitian symmetric spaces will be classified. The corresponding situation in some natural generalizations of Riemannian symmetric spaces will also be discussed. (Received September 22, 2012)

1086-53-1478 **Ralph J Bremigan*** (bremigan@bsu.edu), Department of Mathematical Sciences, Ball State University, Muncie, IN 47306-0490. *A hyperkähler structure on the cotangent bundle of a complex semisimple Lie group.* Preliminary report.

Let G be a complex semisimple group, the complexification of a compact Lie group K . P.B. Kronheimer (1988 MSRI preprint) used Nahm's equations to prove the existence of a $K \times K$ -invariant hyperkähler structure on the cotangent bundle of G . We will report on progress in describing this hyperkähler structure using elementary Lie theory. (Received September 22, 2012)

1086-53-1479 **Charles P Boyer*** (cboyer@math.unm.edu), Department of Mathematics and Statistics, MSC01 1115, 1, University of New Mexico, Albuquerque, NM 87131. *The Join Construction and Extremal Sasakian Geometry.* Preliminary report.

My talk is based on joint ongoing work with Christina Tønnesen-Friedman. We give a general approach using the join construction in Sasakian geometry to describe extremal Sasaki metrics on a host of smooth contact manifolds. Such structures often occur in bouquets of Sasaki cones. We briefly describe these in the case of S^3 -bundles over Riemann surfaces of arbitrary genus as well as certain Sasakian manifolds with a perfect fundamental group arising as the join with homology 3-spheres. (Received September 22, 2012)

1086-53-1486 **J. Arlo Caine*** (jacaine@csupomona.edu) and **Doug Pickrell** (pickrell@math.arizona.edu). *Homogeneous Poisson Structures on Symmetric Spaces.*

Applying a general construction in Poisson geometry due to Evens and Lu, we compute in an explicit way Poisson structures on compact and dual non-compact type symmetric spaces which are determined by the choice of a compact real form and a Borel subalgebra of the Lie algebra of the common complexification of the their isometry groups. This decomposes each such symmetric space into a union of symplectic manifolds, each of which turns out to support a natural completely integrable system. A corollary of our calculations is that the hamiltonian system arising in the noncompact case is isomorphic to the generic hamiltonian system arising in the dual compact case. (Received September 22, 2012)

1086-53-1496 **D Sean Fitzpatrick*** (sean@math.berkeley.edu), 749 Evans Hall #3840, Department of Mathematics, University of California, Berkeley, Berkeley, CA 94704. *Dirac-like operators on subbundles and Toeplitz structures on contact manifolds.* Preliminary report.

This will be a discussion of some current work in progress related to geometric quantization in the setting of contact geometry. In the appendix to their book “The Spectral Theory of Toeplitz Operators”, Boutet de Monvel and Guillemin describe what they call “contact quantization”: a proof that any (coorientable) contact manifold admits a Toeplitz structure. On the other hand, one can approach contact quantization from the point of view of index theory for Spin^c Dirac operators, getting around the fact that a contact manifold is odd-dimensional by constructing an operator that is only transversally elliptic, in the case of a smooth Lie group action whose orbits are transverse to the contact distribution. I will discuss what these approaches have in common, and some questions I have about the relationship between them. (Received September 22, 2012)

1086-53-1557 **Daniele Grandini*** (grandini.math@gmail.com), 6704 Los Prados Rd NW, Albuquerque, NM 87114. *Holomorphic Poisson cohomology and generalized complex geometry.* Preliminary report.

In the talk I will present holomorphic Poisson cohomology from the point of view of generalized complex geometry. Holomorphic Poisson structures can be seen as extended deformations of complex manifolds and holomorphic Poisson Cohomology can be interpreted either as a “deformed Dolbeault Cohomology” or a “generalized Dolbeault Cohomology”. I will focus on the holomorphic Poisson spectral sequence (i.e., the spectral sequence that computes the Poisson cohomology) and show its relation to the Hodge-deRham spectral sequence. The talk is based on my current work with Yat-Sun Poon. (Received September 23, 2012)

1086-53-1562 **Yonggang Shi*** (yshi@loni.ucla.edu), **Rongjie Lai** and **Arthur Toga**. *Conformal Metric Optimization on Surfaces (CMOS) for Mapping Neuroanatomical Shapes.*

In this work, we present a novel method for surface mapping and its application in group studies of neuroanatomical surfaces. Using Laplace-Beltrami eigen-functions, we first construct an intrinsic embedding of 3D surfaces. To account for non-isometry differences between surfaces, we iteratively optimize the conformal metrics on surfaces and find the maps in the embedding space. We will demonstrate the novel mapping algorithm on studying various brain shapes in clinical applications. (Received September 23, 2012)

1086-53-1747 **Mihai Bailesteanu*** (mbailest@z.rochester.edu). *$\text{Spin}(7)$ Manifolds - Old and new.*

$\text{Spin}(7)$ manifolds are 8 dimensional Riemannian manifolds that have a cross product on their tangent bundles, which generate a 4-form. We can define some canonical vector fields on these manifolds, which in turn allows us to define some type of moment map. The goal of having a moment map is to study the topology of the underlying manifold. We will discuss some recent developments. (Received September 24, 2012)

1086-53-1840 **Nicholas R Pasko*** (nrpasko@smcm.edu), Campus Center #1749, 16800 Point Lookout Rd., St. Marys City, MD 20686, and **Casey J Douglas**. *Gaussian Lines and Circles.* Preliminary report.

In this talk we discuss curves that exhibit self-similarity under mean curvature flow. Our approach uses undergraduate-friendly mathematics and reproduces the classification proven by Abresch and Langer. However, we also discuss connections to other areas (including Quantum Mechanics and manifolds with density) as well as new generalizations, enlarging the class of curves to so-called “Gaussian Lines” and “Gaussian Circles.” (Received September 24, 2012)

1086-53-1855 **Cheryl Balm*** (balmcher@math.msu.edu). *Cosmetic generalized crossing changes in knots.* We show that if K is a satellite knot which admits a generalized cosmetic crossing change of order q with $|q| \geq 6$, then K admits a pattern knot with a generalized cosmetic crossing change of the same order. As a consequence

of this, we show that if there is any knot admitting a generalized cosmetic crossing change of order greater than 5, then there must be such a knot which is hyperbolic. (Received September 24, 2012)

1086-53-1892 **Jason Cantarella, Tetsuo Deguchi and Clayton Shonkwiler*** (clayton@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Probability Theory of Random Polygons from the Quaternionic Viewpoint.*

I will describe a new measure on closed space and plane polygons which comes from pushing forward Haar measure on certain Stiefel manifolds. The edgelengths of polygons sampled according to this measure obey beta distributions. This makes these polygon measures different from those usually studied, which have Gaussian or fixed edgelengths. One advantage of these measures is that expectations and moments for chordlengths and radii of gyration can be explicitly computed. Another is that direct sampling according to these measures is fast (linear in the number of edges) and easy to code. (Received September 24, 2012)

1086-53-1966 **Jeffrey Jauregui*** (jauregui@math.upenn.edu) and **William Wylie.** *Conformal diffeomorphisms of gradient Ricci solitons and generalized quasi-Einstein manifolds.*

We extend some well-known rigidity results for conformal changes of Einstein metrics to the class of generalized quasi-Einstein (GQE) metrics, which includes gradient Ricci solitons. In order to do so, we introduce the notions of conformal diffeomorphisms and vector fields that preserve a GQE structure. We show that a complete GQE metric admits a structure-preserving, non-homothetic complete conformal vector field if and only if it is a round sphere. We also classify the structure-preserving conformal diffeomorphisms. In the compact case, if a GQE metric admits a structure-preserving, non-homothetic conformal diffeomorphism, then the metric is conformal to the sphere, and isometric to the sphere in the case of a gradient Ricci soliton. (Received September 24, 2012)

1086-53-1972 **Dechang Chen*** (cdcchenny@gmail.com), Math& Stats Department, University of Massachusetts, Amherst, MA 01002. *Area growth of surfaces with bounded mean curvature.*

In this paper, we give lower volume growth estimates for a complete noncompact hypersurface M with bounded mean curvature in a complete n -manifold N with bounded mean curvature and positive injectivity radius, where M is allowed to have compact boundary. Then we will show some applications of this result. (Received September 24, 2012)

1086-53-2023 **Fatima Mahmood*** (fmahmoo2@z.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627. *Jacobi Structures on Contact Quotients.*

A Jacobi structure on a manifold is a pair (Λ, E) , where Λ is a bivector field and E is a vector field, that satisfies certain properties. The Jacobi structure gives rise to a Jacobi bracket on the algebra of smooth functions on the manifold. This can be generalized to the notion of a Jacobi bracket on an abstract commutative algebra. A contact quotient is the orbit space of a certain subset of a contact manifold under an action of a Lie group. Contact quotients are in general singular but have stratifications into contact manifolds. In this talk, we will review the notion of differential forms on contact quotients and define a Jacobi bracket on the algebra of 0-forms on the quotient. We will relate the Jacobi structure on the total quotient space to the one present on each stratum. (Received September 24, 2012)

1086-53-2502 **Derek Habermas*** (habermas@potsdam.edu). *Decompositions of compact symmetric spaces.*

Let U/K be a connected, compact symmetric space, θ an involution of U that fixes K , G the complexification of U , and $\phi : U/K \rightarrow U \subset G$ the Cartan embedding. Intersecting $\phi(U/K)$ with the Bruhat decomposition of G , corresponding to a θ -stable triangular factorization of the Lie algebra of G , gives us a decomposition of the symmetric space indexed by the Weyl group W of G . We will show explicit computations of representatives, in the normalizer of a maximal torus in U , of the connected components of the generic part of this decomposition. We will also discuss necessary and sufficient conditions to determine if a given $w \in W$ corresponds to a cell that has a non-empty intersection with $\phi(U/K)$. (Received September 25, 2012)

1086-53-2813 **Jason Bello*** (jbello01@yahoo.com), 424 Veteran Ave. #106, Los Angeles, CA 90024, and **Yiran Li and Robert Strichartz.** *Hodge-deRham Theory of K -Forms on Carpet Type Fractals.* Preliminary report.

There have been several approaches to developing an analogue of the Hodge-deRham theory of k -forms on the Sierpinski gasket (SG) and other post-critically finite (pcf) fractals. In this paper we extend the approach in [ACSY] to the Sierpinski carpet (SC) and a related fractal that we call the magic carpet (MC). These fractals are not finitely ramified, and this creates technical difficulties in proving that the conjectured theoretical framework is valid. On the other hand, the structure of “2-dimensional” cells intersecting along “1-dimensional” edges

allows for a nontrivial theory of 2-forms. Our results are largely experimental, but they lead to a conjectured theory that is more coherent than for SG. (Received September 25, 2012)

54 ► General topology

1086-54-256 **Kathleen Grace Kennedy*** (kgracekennedy@math.ucsb.edu), 775 Juniper Walk, Apt. D, Goleta, CA 93117. *A Diagrammatic Multivariate Alexander Invariant of Tangles.*

In 1923, Alexander discovered the Alexander Polynomial of a knot, which can tell if certain knots are distinct. About fifty years later, Conway published a multivariable version of the Alexander polynomial that could help distinguish links. He also defined the skein relation that provided a pictorial way of calculating the original single variable polynomial. Last year, Stephen Bigelow gave a new diagrammatic method for calculating the Alexander polynomial of a knot by resolving crossings of a knot or link in a planar algebra. I will present my multivariable version of Stephen Bigelow's calculation, which is the Multivariable Alexander Polynomial defined by Conway. One advantage of my algorithm is that it generalizes to a multivariable tangle invariant up to Reidemeister I. (Received August 14, 2012)

1086-54-297 **Laura Zirbel*** (lzirbel@math.ucsb.edu). *Knots in thick, self avoiding random walks in 3-space.* Preliminary report.

We describe a new, ergodic algorithm to generate random walks of specified thickness in \mathbb{R}^3 . We use the data resulting from our implementation of this method to investigate the relationship between the presence and nature of knotting and length and thickness of the random walk. (Received August 16, 2012)

1086-54-299 **Melanie DeVries*** (s-mdevrie4@math.unl.edu), Department of Mathematics, 203 Avery Hall, Lincoln, NE 68588-0130. *Unknotting Moves of Virtual Knots.* Preliminary report.

Virtual knot theory is an extension of knot theory originated by Lou Kauffman that gives a framework to study knots embedded in spaces of higher genus and examine the field in a more purely combinatorial sense. Unknotting moves - operations that can transform any knot into the unknot - have been a subject of interest in classical knot theory for many years as they can help create and calculate invariants. As every knot is a virtual knot, virtual knot theory gives us avenues to find new unknotting moves through combinatorial rather topological proofs. This poster will look at some unknotting moves of virtual knots and how to find them. (Received August 17, 2012)

1086-54-654 **Gangadhar R Hiremath*** (gangadhar.hiremath@uncp.edu), Dept of Math and Comp Sci, PO Box 1510, One University Drive, UNCP, Pembroke, NC 28372. *Countable Paracompactness, Invariance under Clopen Mappings, and Metrization.* Preliminary report.

A topological space X is said to have a topological property $(*)$ if and only if each countable closed discrete subset $A = \{x_n | n \text{ is a natural number}\}$ of X admits a countable locally finite open collection $\{G_n | n \text{ is a natural number}\}$ such that for each n , $G_n \cap A = \{x_n\}$. Every countably paracompact space satisfies $(*)$. This article contains the following results:

1. A topological space X is regular if the space is either a Hausdorff first countable space with $(*)$ or a countably paracompact space in which points are regular G_δ .
 2. A second countable space is metrizable if and only if the space is a Hausdorff space with $(*)$ (and hence, the space is a Hausdorff countably paracompact space).
 3. A T_1 completely regular space is countably compact if and only if the space is a pseudocompact space with $(*)$.
 4. The following spaces are invariant under clopen (= continuous closed and open) mappings:
 - (i) Countably paracompact Moore spaces
 - (ii) Hausdorff countably paracompact developable spaces
 - (iii) T_1 countably paracompact developable spaces
 - (iv) T_1 second countable spaces satisfying $(*)$
 - (v) Hausdorff isocompact wM spaces
- (Received September 10, 2012)

1086-54-1082 **Michael M. Yoshizawa*** (myoshi@math.ucsb.edu), Department of Mathematics, South Hall, Room 6607, University of California, Santa Barbara, CA 93106. *High Distance Heegaard Splittings via Dehn Twists.*

In 2001, J. Hempel found examples of Heegaard splittings of arbitrarily high distance by starting with the double of a handlebody H and then applying a high power of a pseudo-Anosov map on the surface ∂H . We show that

lower bounds on distance can also be obtained when using a high power of a suitable Dehn twist. In certain cases, this lower bound allows us to determine the exact distance of the resulting splitting. This is one of the first explicit constructions of Heegaard splittings of high distance whose exact distance can be determined. (Received September 18, 2012)

1086-54-1688 **Eric Hanson*** (hanson@math.colostate.edu), Department of Mathematics, 101 Weber Building, Colorado State University, Fort Collins, CO 80523-1874, **Elizabeth Munch** (emunch@math.duke.edu), Mathematics Department, Duke University, and **Russ Thompson** (russ@math.tamu.edu), Department of Mathematics, Texas A&M University. *A Method for Collapsing Loops in Reeb Graphs of Noisy Data*. Preliminary report.

From a continuous function $f : X \rightarrow \mathbb{R}$ on a topological space X , one can construct a Reeb Graph. This graph summarizes the component structure of the level sets $f^{-1}(a)$, as the value a varies. In applications, Reeb Graphs may be constructed from noisy data that approximate some topological space. Thus there may be features (branches or loops) in the graph that do not correspond to actual topological features of the structure underlying the data, but rather correspond to noise. We present a method of collapsing loops whose persistence is below some small threshold ϵ , which are the loops corresponding to noise. We assert that our method will only change the persistence of other loops by at most 2ϵ and present progress in proving our claim. (Received September 24, 2012)

55 ► Algebraic topology

1086-55-431 **Daniel A Ramras*** (ramras@nmsu.edu) and **Thomas Baird**. *Stable representation theory and the geometry of flat connections*.

In the 1960's, Atiyah and Segal studied the map $R(G) \rightarrow K(BG)$ sending a representation of G to the induced bundle over the classifying space BG . We consider a natural generalization of this map to spherical families of (finite-dimensional, unitary) representations of infinite discrete groups. This topological Atiyah-Segal map is closely linked to the natural map $\text{Hom}(G, U(n)) \rightarrow \text{Map}(BG, BU(n))$, and is thereby related to various questions about (families of) flat bundles over BG . On the other hand, this map can be described in terms of a homotopy limit problem for Carlsson's deformation K-theory functor. This brings methods from stable homotopy theory to bear, leading to various results for (products of) aspherical surfaces, tori, and flat manifolds. Parts of this work are joint with Tom Baird. (Received September 01, 2012)

1086-55-442 **Noureen Khan*** (noureen.khan@unt.edu), 7300 University Hills Blvd., Dallas, TX 75007. *On Warping Degree of Virtual Knot Diagram*.

We define and study the Warping Degree $W(D_v)$ for an oriented virtual knot diagram D_v , as an invariant of a virtual knot diagram. The warping degree has been studied for the classical knots [1], our work present its generalization for virtual knots.

Keywords: Virtual Knots, Crossing number, Warping Degree

[1] A. Shimizu, The Warping Degree of a Knot Diagram, Journal of Knot Theory with Ramifications, (19,7) (2010) pp. 849—857. (Received September 26, 2012)

1086-55-798 **Jennifer Lazarus***, 7300 Houston School Rd, Dallas, TX 75241, and **Noureen Khan**. *Tangle Solutions for Site-Specific Hin Recombinase on DNA*.

The tangle model was developed by Ernst and Summers, to analyze enzymatic reactions on DNA [2]. Recombinases act on DNA by changing crossover sites by inverted repeats or direct repeats [3]. Previously, the tangle model was created to describe the processive recombination of enzymes with DNA; which produced four-plats as products. Results from biological observations and topological analysis aid in adjusting the tangle model to handle the tangle equations of distributive recombination; which produces composite knots as some products [1]. Hin recombinase acts on DNA by both processive and distributive recombination. We explore the adjustment of the tangle model to distributive recombination using Hin recombinase. Keywords: DNA, Tangle model, Four-plats, Recombinase, Hin recombinase References [1] D. Buck and M. Mauricio, Tangle solutions for composite knots: application to Hin recombination, arXiv: 1007.0948v1 [math.GT], 1-17, 2010 [2] C. Ernst, D.W. Summers, A calculus for rational tangles: applications to DNA recombination, Math. Proc. Camb. Phil. Soc., 108, 409, 1990 [3] M. Vazquez and D.W. Summner; Tangle analysis of Gin site-specific recombination, Math. Proc. Camb. Phil. Soc., 136, 2004 (Received September 12, 2012)

- 1086-55-846 **Jonathan Kirkpatrick Sullivan*** (noureen.khan@unt.edu), 7300 Houston School Rd, Dallas, TX 75241, and **Noureen Khan**. *Computational Implementation of Ernst's Tangle Equations Model*.

The "knotting" of bio structures has recently been attributed to competitive advantage in evolution. C. Ernst presented Tangle Equations model, to find the O,P,R, for given $N(O + P)$ and $N(O + R)$. In this paper we compute same results by JAVA implementation of Tangle Equations Model. We also discuss the involvement of knot theory in study of life, the basics that build up to understanding and solving tangle equations. (Received September 13, 2012)

- 1086-55-981 **Brooke Shipley***, 508 Science and Engineering Offices (m/c 249), 851 S. Morgan Street, Chicago, IL 60607-7045, and **Kathryn Hess**. *The homotopy theory of coalgebras over a comonad*.

Let K be a comonad on a model category M . We provide conditions under which the associated category of K -coalgebras admits a model category structure such that the forgetful functor to M creates both cofibrations and weak equivalences. We will provide concrete examples that satisfy our conditions and are relevant in descent theory and in the theory of Hopf-Galois extensions in the differential graded context, and will also mention on-going work in pointed sets and spectra. (Received September 17, 2012)

- 1086-55-1100 **Kate Poirier***, 970 Evans Hall, Department of Mathematics, UC Berkeley, Berkeley, CA 94720. *Compactifying String Topology*.

String topology studies the algebraic topology of the space of loops and paths in a manifold. Previous treatments of string topology describe algebraic structures on the homology of this space and operations parameterized by the moduli space of Riemann surfaces. One perspective is that these structures should be a shadow of a richer structure at the chain level and that the space parametrizing the operations should be compactified. In this talk, we describe a compact space of graphs giving string topology operations on the singular chains of the space of loops and paths which induce known operations on homology. This is joint work with Gabriel C. Drummond-Cole and Nathaniel Rounds. (Received September 18, 2012)

- 1086-55-1297 **Bruce R Corrigan-Salter*** (brucecor@buffalo.edu), 244 Mathematics Building, Buffalo, NY 14260. *Rigidification of homotopy algebras over multi-sorted semi-theories*. Preliminary report.

Multi-sorted algebraic theories provide a formalism for describing various structures on spaces that are of interest in homotopy theory. The results of Badzioch and Bergner showed that an interesting feature of this formalism is the following rigidification property. Every multi-sorted algebraic theory defines a category of homotopy algebras, i.e. a category of spaces equipped with certain structure that is to some extent homotopy invariant. Each such homotopy algebra can be replaced by a weakly equivalent strict algebra which is a purely algebraic structure on a space. The equivalence between the homotopy categories of loop spaces and topological groups is a special instance of this result.

In this talk we will introduce the notion of a multi-sorted semi-theory which is a useful generalization of a multi-sorted algebraic theory. We will show that in the setting of multi-sorted semi-theories we can still obtain results paralleling these of Badzioch and Bergner, although a rigidification of a homotopy algebra over a multi-sorted semi-theory is given by a strict algebra over a certain resolution of that semi-theory. This extends the result obtained by Badzioch for single-sorted semi-theories. (Received September 20, 2012)

- 1086-55-1462 **William G Dwyer*** (dwyer.1@nd.edu), University of Notre Dame, Department of Mathematics, Notre Dame, IN 46556, and **Kathryn Hess** (kathryn.hess@epfl.ch), EPFL AA EDMA-GE, MA B2 424 (Batiment MA), Station 8, CH-1015 Lausanne, Switzerland. *Configuration spaces and operad actions*. Preliminary report.

The talk will describe how operad actions on configuration spaces can sometimes be used to express more complicated configuration spaces in terms of simpler ones. The key ingredient is an external tensor product construction for modules over operads. (Received September 22, 2012)

- 1086-55-1789 **Yuriy Mileyko*** (ymileyko@lavabit.com), **Sayan Mukherjee**, **Katharine Turner** and **John Harer**. *Probability measures on the space of persistence diagrams*.

Persistence diagrams are topological summaries that provide useful information about the topology and geometry of data and play a crucial role in topological data analysis. However, the problem of quantifying the uncertainty, noise, and reproducibility of these topological summaries, which is a fundamental aspect of the classical data analysis, has not been well studied. In this talk, we shall show that the space of persistence diagrams has properties that allow for the definition of probability measures which support expectations, variances, percentiles

and conditional probabilities. This provides a theoretical basis for a statistical treatment of persistence diagrams, for example computing sample averages and sample variances of persistence diagrams, and allows us to extend the theory of topological persistence to a much larger set of applications. We shall also present an algorithm for computing sample averages of persistence diagrams. (Received September 24, 2012)

1086-55-2085 **Ryan Wayne Gryder*** (rwgryder@email.wm.edu), 3808 East Steeplechase Way, Apartment K, Williamsburg, VA 23185. *Global Dynamics of Pulse-Coupled Oscillators*. Preliminary report.

This research extended work done by a previous student, Allison Corish, on the dynamics of pulse-coupled oscillators on networks. Allison's project laid the groundwork through construction of a numerical technique which rigorously proved the existence of fixed points and connecting orbits for a collection of three oscillators coupled via a directed 3-cycle. This algorithm was automated to allow for arbitrary parameters such as heterogeneous coupling strengths and different network topologies. Currently the focus is to create a database of rigorously constructed dynamical behavior over a suitable parameter space. (Received September 24, 2012)

1086-55-2120 **Nicholas D. Nguyen*** (ndn004@math.ucsd.edu). *Exceptional Lie Groups, Commutators, and Commutative mod 3 Homology Rings*. Preliminary report.

The multiplication μ of a Lie group G induces an associative ring structure on its mod 3 homology $H_*(G; \mathbb{F}_3)$. In the case that $H_*(G; \mathbb{Z})$ has no 3-torsion, $H_*(G; \mathbb{F}_3)$ will be a (graded) commutative ring. However, if $H_*(G; \mathbb{Z})$ has 3-torsion, then $H_*(G; \mathbb{F}_3)$ will not be commutative. In particular, four of the five exceptional Lie groups have 3-torsion in their integral homology groups.

Nevertheless, we will find a different multiplication map ν on G which will make (G, ν) an H-space with $H_*(G; \mathbb{F}_3)$ a commutative ring (using ν_* as the ring multiplication). Furthermore, we construct ν using μ and the commutator map for the Lie group (G, μ) . In addition, we will generalize the process beyond Lie groups to finite simply-connected homotopy-associative H-spaces, and to odd primes larger than 3. (Received September 25, 2012)

1086-55-2550 **Carolyn M. Yarnall*** (cmY3d@virginia.edu). *Determining Slice Towers*. Preliminary report.

The slice filtration is a filtration of equivariant spectra developed by Hill, Hopkins, and Ravenel in their solution to the Kervaire Invariant One Problem. After briefly discussing some basic properties of the slice filtration, I will talk about methods for computing slice towers by looking at a particular example. (Received September 25, 2012)

1086-55-2616 **Marcy Robertson***, Department of Mathematics-Middlesex, University of Western Ontario, London, Ontario N6A 5B7, Canada, and **Andrew Salch** and **Julie Bergner**, University of California Riverside. *On Topological Triangulated Orbit Categories*.

In 2005, Keller showed that the orbit category associated to the bounded derived category of a hereditary category under an auto equivalence is triangulated. As an application he proved that the cluster category is triangulated. We show that this theorem generalizes to triangulated categories with topological origin (i.e. the homotopy category of a stable model category). As an application we construct a topological triangulated category which models the cluster category. This is joint work with Andrew Salch. (Received September 25, 2012)

1086-55-2833 **Kathryn L. Nyman** and **Francis Edward Su*** (su@math.hmc.edu), Department of Mathematics, Harvey Mudd College, 301 Platt Blvd, Claremont, CA 91711. *A Borsuk-Ulam equivalent that directly implies Sperner's Lemma*.

We show that Fan's 1952 lemma on labelled triangulations of the n -sphere with $n + 1$ labels is equivalent to the Borsuk-Ulam theorem. Moreover, unlike other Borsuk-Ulam equivalents, this lemma directly implies Sperner's Lemma, so this proof may be regarded as a combinatorial version of the fact that the Borsuk-Ulam theorem implies the Brouwer fixed point theorem, or that the Lusternik-Schnirelmann-Borsuk theorem implies the KKM lemma. (Received September 25, 2012)

57 ► Manifolds and cell complexes

1086-57-28 **Louis Hirsch Kauffman*** (kauffman@uic.edu), 5530 South Shore Drive, Apartment 7C, Chicago, IL 60637-1946. *Knot Invariants and Functional Integration*. Preliminary report.

This talk will revisit the subject of defining quantum link invariants and formulating loop quantum gravity theory by using functional integrals, integrating over gauge connections. We will look at those properties of this subject

that can be seen via the equivalence classes of functions on gauge connections where two such are equivalent if their difference is the gauge functional derivative of a function on connections that is rapidly vanishing at infinity. (Received May 31, 2012)

1086-57-127 **R. Taylor McNeill*** (rtm2@rice.edu). *A new filtration of the Magnus kernel of the Torelli group.*

For a surface Σ , the Torelli group is the group of orientation preserving homeomorphisms of Σ that induce the identity on homology. The Magnus representation represents the action on F/F'' where $F = \pi_1(\Sigma)$ and F'' is the second term of the derived series. For many years it was unknown whether the Magnus representation of the Torelli group is faithful. In recent years there have been many developments on this front including the result of Church and Farb that the kernel of the Magnus representation, denoted K , is infinitely generated. I show that, not only is K highly non-trivial but that it also has a rich structure as a group. Specifically, I define an infinite filtration of K by subgroups, called the higher order Magnus subgroups, M_n . I show that for each n the quotient M_n/M_{n+1} is infinitely generated. To do this, I define a Johnson type homomorphism on each higher order Magnus subgroup quotient and show it has a highly non-trivial image. (Received July 26, 2012)

1086-57-159 **Danielle O'Donnol*** (dodonnol@imperial.ac.uk) and **Elena Pavelescu**. *Legendrian θ -graphs.*

We investigate Legendrian θ -graphs in \mathbb{R}^3 with the standard contact structure. We define the invariants Thurston-Bennequin number, tb , and rotation number, rot , for Legendrian graphs. We determine which Thurston-Bennequin number and rotation number can be realized for a Legendrian θ -graph that is topologically planar. We investigate whether these invariants determine the graph up to Legendrian isotopy. Additionally, we look at the relationship between a Legendrian θ -graph and the transverse boundary of the its Legendrian ribbon. (Received July 31, 2012)

1086-57-176 **Stephen F Sawin*** (ssawin@fairfield.edu), 1073 N. Benson Rd, Fairfield CT, CT 06825, and **Lauren Ellenberg** (laellenberg@gmail.com), **Gabriella Newman** (newmang@carleton.edu) and **Jonathan Shi** (jshi@cs.washington.edu). *A subexponential algorithm for computing the Kauffman bracket of a link or tangle.* Preliminary report.

We prove that the Kauffman bracket polynomial of a link (and the representation of a tangle in the Kauffman bracket skein module) can be computed with time and space exponential in the square root of the number of crossings, giving explicit bounds on the costs. This involves generalizing results on the span of the Kauffman bracket to tangles, and most importantly bounding the girth of a link (or more precisely the modified girth) by a certain multiple of the square root of the number of crossings. these results should be crucial ingredients for proving similar bounds on the computation of Khovanov Homology. (Received August 03, 2012)

1086-57-217 **David K. Heywood*** (davaudoo@mail.fresnostate.edu) and **Dionne F. Ibarra**. *A state model for the two-variable Kauffman polynomial.* Preliminary report.

The two-variable Kauffman polynomial and the HOMFLY-PT polynomial for links are distinct, with different topological properties. Francois Jaeger showed that there is a beautiful relationship between these link invariants, by presenting the Kauffman polynomial of an unoriented link L as a weighted sum of HOMFLY-PT polynomials of oriented links associated with L . Murakami, Ohtsuki and Yamada (MOY) constructed a state model for the HOMFLY-PT polynomial via planar graphs (flattenings of oriented link diagrams) and a recursive evaluation of these graphs.

We apply the MOY framework to Jaeger's work, and construct a state summation model for the two-variable Kauffman polynomial via planar 4-valent graphs.

This work is partially sponsored by the Undergraduate Research Grant program at California State University, Fresno, under the supervision of Professor Carmen Caprau. (Received August 07, 2012)

1086-57-218 **Carmen L. Caprau*** (ccaprau@csufresno.edu), Department of Mathematics, California State University, Fresno, CA 93740. *Foams and $sl(n)$ tangle cohomology.* Preliminary report.

We construct an integer (co)homology theory for tangles via a special type of dotted foams and 4-valent webs, which for the case of closed tangles, thus links, is a categorification of the quantum $sl(n)$ link polynomial (for $n > 3$).

Our construction uses a rank n Frobenius extension and its associated 2-dimensional TQFT with dots, together with a Bar-Natan type tautological functor, and provides efficient computations of the resulting invariant. Moreover, our link homology is isomorphic to Khovanov-Rozansky link homology. (Received August 07, 2012)

- 1086-57-344 **Moshe Cohen*** (cohenm10@macs.biu.ac.il), Department of Mathematics, Bar-Ilan University, 52900 Ramat Gan, Israel. *A perfect matching model for knot homology theories.* Preliminary report.

Spanning tree models for knot homology theories (including those of Greene, Roberts, and Baldwin and Levine) have combinatorial generators but more complicated differentials that need to pass through non-spanning-tree resolutions. Using the dimer model studied previously by this author, the differential can now be realized as a combinatorial object, as well, and thus can be better understood. Preliminary results are discussed. (Received August 23, 2012)

- 1086-57-382 **Martin Scharlemann*** (mgscharl@math.ucsb.edu), Mathematics Department MC3080, University of California, Santa Barbara, CA 93105-3080. *Proposed Property 2R counterexamples classified.*

Earlier work with Robert Gompf and Abigail Thompson classified, via a natural slope indexed by \mathbb{Q} , all two-component links which contain the square knot and from which $(S^1 \times S^2) \# (S^1 \times S^2)$ can be obtained by surgery. It was argued there that each of a certain family L_n of such links probably contradicts the Generalized Property R Conjecture. Left unresolved was how the family L_n fits into the classification scheme. This question is resolved here, in part by giving varied perspectives and more detail on the construction of the L_n . (Received August 27, 2012)

- 1086-57-485 **Taylor E Martin*** (taylor.martin@rice.edu). *Classification of 0-solvable links and results about 0.5-solvability.*

The n -solvable filtration, defined by Cochran, Orr, and Teichner in the late 90's, gives structure to the smooth knot and link concordance groups. Much is known about the n -solvable filtration of the knot concordance group for small n . For example, a knot is 0-solvable if and only if it has Arf invariant zero. Moreover, a knot is 0.5-solvable precisely when its Seifert matrix looks like that of a slice knot, called algebraically slice. However, very little is known for links. In this talk, we will completely classify 0-solvable links and discuss recent progress toward understanding 0.5-solvable links, including some necessary conditions. (Received September 04, 2012)

- 1086-57-491 **Candice Renee Price*** (candice.r.price@gmail.com). *Biological Application for the Oriented Skein Relation.*

The traditional skein relation for the Alexander polynomial involves an oriented knot, K_+ , with a distinguished positive crossing; a knot K_- , obtained by changing the distinguished positive crossing of K_+ to a negative crossing; and a link K_0 , the orientation preserving resolution of the distinguished crossing. We refer to (K_+, K_-, K_0) as the *oriented skein triple*.

Topoisomerases are proteins that break one segment of DNA allowing a DNA segment to pass through before resealing the break. Effectively, the action of these proteins can be modeled as $K_- \Leftrightarrow K_+$. *Recombinases* are proteins that cut two segments of DNA and recombine them in some manner. While recombinase local action varies, most are mathematically equivalent to a resolution, i.e. $K_{\pm} \Leftrightarrow K_0$. The oriented triple is now viewed as $K_- =$ circular DNA substrate, $K_+ =$ product of topoisomerase action, $K_0 =$ product of recombinase action.

The theorem stated in this work gives a relationship between two 2-bridge knots, K_+ and K_- , that differ by a crossing change and a link, K_0 created from the oriented resolution of that crossing. We apply this to *difference topology* experiments using topoisomerase proteins to study SMC proteins. (Received September 04, 2012)

- 1086-57-506 **Neil R Hoffman*** (nhoffman@mpim-bonn.mpg.de). *On knot complements that decompose into regular ideal dodecahedra.*

We show that there are only two knot complements that can be decomposed into regular ideal dodecahedra, providing a partial solution to a conjecture of Neumann and Reid. (Received September 05, 2012)

- 1086-57-596 **Tye Lidman and Ciprian Manolescu*** (cm@math.ucla.edu), UCLA, Mathematics Department, 520 Portola Plaza, Los Angeles, CA 90095. *Monopole Floer homology and covering spaces.*

I will discuss a Smith-type inequality for regular covering spaces in monopole Floer homology. We use the definition of monopole Floer homology as the homology of the Seiberg-Witten-Floer spectrum. There is a notion of spectrum-L-space, which is conjecturally the same as an L-space. A corollary of the main theorem is that if an oriented 3-manifold Y admits a p^n -sheeted regular cover that is a Z/p -spectrum-L-space (for p prime), then Y itself is a Z/p -spectrum-L-space. (Received September 08, 2012)

1086-57-614 **Kenneth C Millett*** (millett@math.ucsb.edu), Department of Mathematics, UCSB, Santa Barbara, CA 93106. *Knots in proteins and their implications.*

Identifying the fine structure of knots and slipknots in proteins is a challenging but significant objective. One method of accomplishing this task leads to the identification of a knotting fingerprint for each structure. Its strict conservation within and between protein families despite large sequence divergence provides suggestions as to their functional role. We will discuss the method, its application to protein structures, and possible implications. This is joint work with Eric Rawdon, Andrzej Stasiak, Joanna Sulkowska, and Jose Onuchic. (Received September 09, 2012)

1086-57-733 **Bo-hyun Kwon*** (bohykwon@math.okstate.edu), 2011 S. Devin Lea Street, stillwater, OK 74074. *An algorithm to classify rational 3-tangles.* Preliminary report.

A 3-tangle T is the disjoint union of 3 properly embedded arcs in the unit 3-ball and it is called *rational* if there is a homeomorphism of pairs from (B^3, T) to $(D^2 \times I, \{x_1, x_2, x_3\} \times I)$, where $\{x_1, x_2, x_3\} \times I$ is a trivial tangle. Two rational 3-tangles T and T' are isotopic if there is an orientation-preserving self-homeomorphism $h : (B^3, T) \rightarrow (B^3, T')$ that is the identity map on the boundary. In this paper, we give an algorithm to check whether two rational 3-tangles are isotopic or not by using a modified version of Dehn's method for classifying simple closed curve on surfaces. (Received September 11, 2012)

1086-57-832 **John L Harer*** (john.harer@duke.edu), Department of Mathematics, Duke University, Durham, NC 27514. *Topology, Geometry and Statistics: Merging Methods for Data Analysis.* Preliminary report.

Dimension reduction and shape description for scientific datasets are difficult problems, ones that continue to grow in importance within the statistical, mathematical and computer science communities. Powerful new methods of Topological Data Analysis (TDA) have emerged in the last 10 years, and these have added significantly to the data analysis toolbox.

In this talk we will give an overview of these methods and describe some early efforts to make them work together with statistical approaches. In particular we will discuss how one can use topological priors in data analysis and how TDA applies to the study of shape in point clouds, dimension reduction, time varying data and finding quasi-periodic patterns in signals. (Received September 13, 2012)

1086-57-926 **Ji Li*** (ji.li@uconn.edu), 118 Courtyard Lane, Storrs, CT 06268. *Isotopy Convergence Theorem.*

When approximating a space curve, it is natural to consider whether the knot type of the original curve is preserved in the approximant. This preservation is of strong contemporary interest in computer graphics and visualization. We establish a criterion to preserve knot type under approximation that relies upon convergence in both distance and total curvature. (Received September 23, 2012)

1086-57-945 **Brian A. Benson*** (benson9@illinois.edu), University of Illinois, Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Buser's Inequality and Cheeger Constants of Arithmetic Surfaces.*

Ian Agol recently gave an approach for improving the sharpness of Buser's inequality for compact n -manifolds M , which gives an upper bound for the Cheeger constant of M , $h(M)$, in terms of the first non-zero eigenvalue of the Laplacian of M , $\lambda_1(M)$. A difficulty of Agol's method is that it is given implicitly by a collection of equations, one of which is an ODE. Agol's equations are simplest for $n = 3$, and he used his approach to substantially improve Buser's inequality in that dimension. In recent work, I find the general solution to Agol's ODE for arbitrary n . I will then discuss how Agol's refinement of Buser's inequality can be extended from compact surfaces to any hyperbolic surface with finite area. Selberg's one-quarter conjecture considers a specific sequence of arithmetic surfaces $X(N)$ and speculates that $\lambda_1(X(N)) \leq 1/4$. As an application, using a result of Brooks and Zuk, we show that Selberg's conjecture one quarter conjecture implies that $h(X(N))$ is bounded in a fixed interval of length less than $1/5$ for all but finitely many N . (Received September 16, 2012)

1086-57-1013 **Priyam Patel*** (priyamp@math.rutgers.edu). *Quantifying Residual Finiteness in Terms of Geometric Data.*

This talk will begin by defining what it means for a group to be residually finite (RF) and locally extended residually finite (LERF), followed by a brief history of the results which proved that surface groups and particular 3-manifold groups are RF and LERF. We will then discuss what it means to quantify these group properties and explain the results that allow us to quantify RF-ness and LERF-ness of hyperbolic surface groups in terms of geometric data. We will conclude with an overview of the techniques used to obtain similar quantification results for particular 3-manifold groups. (Received September 17, 2012)

- 1086-57-1158 **Abhijit Champanerkar** and **Philip Ording*** (pording@mec.cuny.edu), Department of Mathematics, Medgar Evers College, CUNY, 1650 Bedford Avenue, Brooklyn, NY 11225. *Quasi-alternating Montesinos links*. Preliminary report.

Quasi-alternating links are a generalization of alternating links. They are homologically thin for both Khovanov homology and knot Floer homology. In this talk we will discuss the quasi-alternating classification for Montesinos links. (Received September 19, 2012)

- 1086-57-1231 **Mladen Bestvina***, Department of Mathematics, University of Utah, 155 S 1400 E Rm 233, Salt Lake City, UT 84112. *Geometric group theory and 3-manifolds hand in hand: the fulfillment of Thurston's vision for three-manifolds*.

In the late 70s, Thurston revolutionized our understanding of 3-manifolds. He stated a far reaching Geometrization Conjecture and proved it for a large class of manifolds, called Haken manifolds. He also posed 24 open problems, describing his vision of the structure of 3-manifolds.

Pieces of Thurston's Vision have been confirmed in the subsequent years. Perelman proved the Geometrization Conjecture (see Morgan's Current Events lecture in 2004), Tameness Conjecture (Agol and Calegari-Gabai), Ending Lamination Conjecture (Brock-Canary-Minsky), and the Surface Subgroup Conjecture (Kahn-Markovic, see Brock's Current Events lecture in 2012). In the meantime, Dani Wise developed a sophisticated program to study objects called cube complexes, and in particular to promote immersions to embeddings in a finite cover. Ian Agol completed Wise's program and as a result essentially all problems on Thurston's list are now solved.

In this talk I will introduce cube complexes and how they are associated to surfaces in 3-manifolds, leading up to the main theorem on cube complexes and how it implies the "virtual Haken conjecture". (Received September 20, 2012)

- 1086-57-1535 **Ronald Fintushel*** (ronfint@math.msu.edu), Department of Mathematics, Michigan State University, E. Lansing, MI 48824. *Constructions of 4-manifolds*.

I will speak about techniques for constructing smooth 4-manifolds. (Received September 23, 2012)

- 1086-57-1567 **Jennifer Hom*** (hom@math.columbia.edu), **Sam Lewallen**, **Tye Lidman** and **Liam Watson**. *Bordered Floer homology and the Seifert form*. Preliminary report.

We study the bordered Floer homology of the 3-manifold with boundary obtained by cutting S^3 along a Seifert surface Σ for a knot K . In particular, we show that this bordered invariant is a categorification of the Seifert form. This is joint work in progress with Sam Lewallen, Tye Lidman and Liam Watson. (Received September 23, 2012)

- 1086-57-1656 **Matthew Hedden** and **Thomas E. Mark*** (tmark@virginia.edu), Department of Mathematics, PO Box 400137, University of Virginia, Charlottesville, VA 22904-4137. *Floer homology and the fractional Dehn twist coefficient*.

An open book decomposition of a 3-manifold Y is essentially a choice of fibered link embedded in Y . For a fibered knot (i.e. a one-component link), the monodromy of the fibration on the complement gives rise to a rational number called the fractional Dehn twist coefficient. This number measures the twisting of the monodromy around the boundary of the fiber surface. I will describe how the Heegaard Floer homology of a 3-manifold Y provides bounds for the fractional Dehn twist coefficient of any open book decomposition of Y with connected binding. This is joint work with Matthew Hedden. (Received September 23, 2012)

- 1086-57-1678 **Liam Watson***, lwatson@math.ucla.edu. *Heegaard Floer homology solid tori*. Preliminary report.

This talk is an attempt to treat and provide context for the following question: what are the simplest bordered Heegaard Floer invariants? We will focus on the case of manifolds with torus boundary and, by analogy with Heegaard Floer homology lens spaces – known as L-spaces – for closed three manifolds, introduce the notion of a Heegaard Floer homology solid torus. These manifolds satisfy a type of Alexander trick at the level of Heegaard Floer homology; the goal of the talk will be to make this precise. We will give some explicit examples and discuss some applications and related questions. (Received September 24, 2012)

- 1086-57-1694 **Roberto C Pelayo*** (robertop@hawaii.edu), University of Hawaii at Hilo, Mathematics Department, Hilo, HI 96720, and **Jesse Johnson** and **Robin Wilson**. *The Coarse Geometry of the Kakimizu Complex*. Preliminary report.

Given a knot $K \subset S^3$, the Kakimizu complex of K is defined as the simplicial complex whose vertices are isotopy classes of minimal genus Seifert surfaces of K , and whose n -simplices are spanned by $n+1$ distinct isotopy classes with pairwise disjoint Seifert surface representatives. Using the JSJ structure of the knot complement, we show

that the Kakimizu complex of any knot in S^3 is quasi-isometric to a Euclidean integer lattice \mathbb{Z}^n for some $n \geq 0$. (Received September 24, 2012)

1086-57-1711 **Denis Auroux, John A. Baldwin** and **J. Elisenda Grigsby*** (grigsbyj@bc.edu), Boston College, Department of Mathematics, 301 Carney Hall, Chestnut Hill, MA 02467, and **Stephan M. Wehrli**. *Categorified invariants and braid conjugacy*.

An "old" construction of Khovanov-Seidel associates to every braid a (homotopy equivalence class of) dg bimodules over an algebra. Their braid invariant is "faithful"—i.e., agrees on two braids iff the braids are the same. In this talk, I will describe a relationship between the Khovanov-Seidel braid invariant and the "sutured annular Khovanov homology" of the braid closure in the solid torus. I will also mention what this and some other categorified invariants can and cannot tell us about braid conjugacy classes. Parts of this talk describe joint work with D. Auroux and S. Wehrli, and other parts describe joint work with J. Baldwin. (Received September 24, 2012)

1086-57-1791 **Ryan Blair, Marion Campisi*** (campisi@math.utexas.edu), **Jesse Johnson, Scott Taylor** and **Maggy Tomova**. *Bridge distance, Heegaard genus, and Exceptional Surgeries*.

We demonstrate a lower bound on the genus of an essential surface or Heegaard surface in a 3-manifold obtained by non-trivial surgery on a link in terms of the bridge distance of a bridge surface for the link. Consequently, knots with high distance bridge surfaces do not admit non-trivial non-hyperbolic surgeries or non-trivial cosmetic surgeries. (Received September 24, 2012)

1086-57-1793 **Stefan Friedl** and **Stefano Vidussi***, svidussi@ucr.edu. *On the Topology of Symplectic 4-Manifolds with $K = 0$* . Preliminary report.

We will discuss some new (or gently used) results and conjectures on the structure of symplectic 4-manifolds with trivial canonical class, focusing on those with positive first Betti number. (Received September 24, 2012)

1086-57-1868 **Stavros Garoufalidis** and **Thomas W Mattman*** (tmattman@csuchico.edu), Department of Mathematics, CSU, Chico, Chico, CA 959290525. *The A -polynomial of the $(-2, 3, 3 + 2n)$ pretzel knots*.

We show that the A -polynomial A_n of the 1-parameter family of pretzel knots $K_n = (-2, 3, 3 + 2n)$ satisfies a linear recursion relation of order 4 with explicit constant coefficients and initial conditions. Our proof combines results of Tamura-Yokota and the second author. As a corollary, we show that the A -polynomial of K_n and the mirror of K_{-n} are related by an explicit $GL(2, \mathbb{Z})$ action. We leave open the question of whether or not this action lifts to the quantum level. (Received September 24, 2012)

1086-57-1885 **Mikhail Lavrov** and **Dan Rutherford*** (drrutherford@uark.edu). *On the HOMFLY-PT invariant of links in $S^1 \times S^2$* .

Gilmer and Zhong showed that there exists an essentially unique invariant that assigns a rational function in a and s to null-homologous links in $S^1 \times S^2$ and satisfies the HOMFLY-PT skein relations. I will discuss joint work with M. Lavrov in which we give explicit formulas for computing this $S^1 \times S^2$ HOMFLY-PT invariant and show that the invariant is in fact a Laurent polynomial in a and $z = s - s^{-1}$. If time permits, I will discuss motivation from Legendrian knot theory. (Received September 24, 2012)

1086-57-1949 **Jeff Erickson*** (jeffe@cs.uiuc.edu). *Transforming Curves on Surfaces Redux*.

Just over 100 years ago, Max Dehn described the first combinatorial algorithm to determine whether two given cycles on a compact surface are freely homotopic, meaning one cycle can be continuously deformed into the other without leaving the surface. We describe a simple variant of Dehn's algorithm that runs in linear time, with no hidden dependence on the genus of the surface. Specifically, given a combinatorial surface of complexity n and two closed vertex-edge walks of length at most ℓ in that surface, our algorithm determines whether the two walks are freely homotopic in $O(n + \ell)$ time. Our algorithm simplifies and corrects a similar algorithm of Dey and Guha and simplifies the more recent algorithm of Lazarus and Rivaud, who identified a subtle flaw in Dey and Guha's techniques. Our algorithm combines components of these earlier algorithms, classical results in small cancellation theory by Gersten and Short, and simple run-length encoding.

This is joint work with Kim Whittlesey. (Received September 24, 2012)

1086-57-2033 **Matthew E Hedden*** (mhedden@math.msu.edu), Department of Mathematics, Wells Hall, East Lansing, MI 48823. *A 4-dimensional interpretation of tightness?*

I'll ask about a 4-dimensional interpretation of what it means for a contact structure on a 3-manifold to be tight, and show that such an interpretation exists for contact structures with non-vanishing Ozsvath-Szabo

contact invariant. I'll also discuss 4-dimensional aspects of the question which asks whether a given open book decomposition yields a tight contact structure. (Received September 24, 2012)

1086-57-2077 **Allison H Moore*** (moorea8@math.utexas.edu), 3504 S. 1st St., Austin, TX 78704. *The total rank conjecture in knot Heegaard Floer homology*. Preliminary report.

Let K be a knot in S^3 with knot Heegaard Floer homology groups $\widehat{HFK}_m(K, s)$. The total rank conjecture asserts that the sum over all bigradings (m, s) of the free ranks of these groups, $\oplus_{m,s} \text{rank} \widehat{HFK}_m(K, s)$, is invariant under Conway mutation, or more generally, genus 2 mutation. We will construct infinitely many examples of genus 2 mutant pairs with invariant total rank and mention some interesting consequences of the conjecture. (Received September 24, 2012)

1086-57-2089 **Jean-Francois Lafont** and **D. B. McReynolds*** (dmcreyno@math.purdue.edu). *Geodesic lengths of arithmetic manifolds*.

I will discuss recent work on the geodesic lengths of arithmetic manifolds. (Received September 24, 2012)

1086-57-2131 **Matthew Hedden** (mhedden@math.msu.edu) and **Adam Simon Levine*** (levinea@brandeis.edu). *Bordered Floer homology and splicing knot complements*.

We use bordered Floer homology to study 3-manifolds obtained by gluing together two knot complements (gluing meridian to longitude). If the knots are non-trivial knots in S^3 , we show that the Heegaard Floer homology of the resulting manifold has rank greater than one. By extending this approach to knots in arbitrary three manifolds, we hope to prove that a manifold whose Heegaard Floer homology has rank one cannot contain an incompressible torus. (Received September 24, 2012)

1086-57-2182 **Aldo-Hilario Cruz-Cota*** (aldo.h.cruz.cota@gmail.com) and **Teresita Ramirez-Rosas**. *Finding Formulas for the Complexity of Riemann Surfaces*.

The *complexity* of a branched cover of a Riemann surface M to the Riemann sphere S^2 is defined as its degree times the hyperbolic area of the complement of its branching set in S^2 . The *complexity* of M is defined as the infimum of the complexities of all branched covers of M to S^2 . We prove that if M is a connected, closed, orientable Riemann surface of genus $g \geq 1$, then its complexity equals $2\pi(m_{\min} + 2g - 2)$, where m_{\min} is the minimum total length of a branch datum realizable by a branched cover $p: M \rightarrow S^2$. Also, we will explain why finding explicit formulas for the integer m_{\min} is a difficult problem that is related to the classical Hurwitz existence problem for branched covers of the Riemann sphere. (Received September 25, 2012)

1086-57-2325 **Dorothy Buck**, **Kai Ishihara**, **Matt Rathbun*** (mrathbun@imperial.ac.uk) and **Koya Shimokawa**. *On cutting fiber surfaces along arcs, and ramifications for DNA*.

Fibered links are those whose complements fiber over the circle, with fibers that are copies of a Seifert surface for the link. It is known that every fibered link can be obtained from the unknot by a sequence of operations called Hopf plumbing and its inverse de-plumbing. Hopf de-plumbing amounts to cutting a fiber of the link along a particular type of arc in the surface. We investigate the problem of when cutting along different arcs might result in a fibered link. The solution to this problem has ramifications in Biology and understanding how certain enzymes interact with DNA. (Received September 25, 2012)

1086-57-2343 **Karene CHU*** (karene@math.utoronto.ca), Department of Mathematics, 6290, Bahen Information Center, 40, St George Street, Toronto, Ontario M5S 2E4, Canada. *Classification of Flat Virtual Pure Tangles and Bases for their Infinitesimal Algebras*.

Virtual knot theory, introduced by Kauffman, is a generalization of classical knot theory of interest because its finite-type invariant theory is potentially a topological interpretation of Etingof and Kazhdan's theory of quantization of Lie bi-algebras. Classical knots inject into virtual knots, and flat virtual knots is the quotient of virtual knots which equates the real positive and negative crossings, and in this sense is complementary to classical knot theory within virtual knot theory.

We classify flat virtual tangles with no closed components and give bases for its "infinitesimal" algebras. The classification of the former can be used as an invariant on virtual tangles with no closed components and virtual braids. We will also show that the infinitesimal algebras are the target spaces of any universal finite-type invariants on the respective variants of the flat virtual tangles, and that they include the space $\mathfrak{U}^{\text{univ}}$ defined by B. Enriquez. (Received September 25, 2012)

1086-57-2477 **Margaret Doig***, mdoig@indiana.edu. *Heegaard Floer theory and finite surgeries*.

I will discuss recent work applying Heegaard Floer theory to questions about knot surgery, including the determination of which elliptic space forms can be constructed as surgery on a knot. If an elliptic space form does

arise as surgery on a knot, I will address the question of what the knot may be. This question is interesting in the context of the Berge (respectively, Dean) Conjecture, which attempts to list the knots that support lens space (respectively, small Seifert fibered) surgeries. (Received September 25, 2012)

1086-57-2668 **Dongxu Wang*** (dxwang1981@gmail.com), 347-02 Pennell Circle, Tallahassee, FL 32310. *3-manifolds of S^1 -cat 3.*

The study of critical points for a smooth function is of great importance in topology. Lusternik and Schnirelmann introduced what is today called Lusternik-Schnirelman category $cat(M^n)$ for a manifold M^n , this is the motivation for the study of category information. I study the category properties for 3-manifolds and try to classify manifolds that can be covered by some open sets that satisfy some homotopy properties. Especially, I classify 3-manifolds that can be covered by three solid tori or solid Klein bottles. (Received September 25, 2012)

1086-57-2674 **Luke Williams*** (will2086@math.msu.edu). *Ribbon Complements.*

Given a ribbon knot K in S^3 , it is straightforward to construct a 4-dimensional handlebody diffeomorphic to the complement of a properly embedded ribbon disk bounding K in B^4 . However, such constructions are by no means canonical. This ambiguity can be used advantageously in constructing differing 4-manifolds with fixed 3-manifold boundary built from 0-surgery on K . (Received September 25, 2012)

1086-57-2781 **Allison L Gilmore*** (gilmore@math.ucla.edu). *An algebraic approach to knot Floer homology.* Preliminary report.

Ozsvath and Szabo gave the first completely algebraic description of knot Floer homology via a cube of resolutions construction. Starting with a braid diagram for a knot, one singularizes or smooths each crossing, then associates an algebra to each resulting singular braid. These can be arranged into a chain complex that computes knot Floer homology. I will discuss generalizations of this construction to framed trivalent graphs and the conjectural relationship of such generalizations to Khovanov and Rozansky's HOMFLY-PT homology. (Received September 25, 2012)

1086-57-2922 **Cody W Armond*** (cody-armond@uiowa.edu) and **Oliver T Dasbach**. *Properties of the head and tail of the colored Jones polynomial.*

The colored Jones polynomial is a link invariant which assigns to each link a sequence of Laurent polynomials. For alternating links (and more generally, adequate links), the leading coefficients stabilize in a way that allows us to define a pair of power series called the head and tail.

We will discuss properties of these power series, such as their dependence on the reduced A and B graphs of a link diagram, and a product structure coming from these graphs. (Received September 26, 2012)

58 ► Global analysis, analysis on manifolds

1086-58-493 **Zhiqin Lu*** (zlu@uci.edu), Department of Mathematics, UC Irvine, Irvine, CA 92697. *On the essential spectrum of complete Riemannian manifolds.*

In this talk, we provide new criteria of a complex number being the essential spectrum of the Laplacians on functions and forms. This is joint work with N. Charalambous. (Received September 04, 2012)

1086-58-498 **Jesús A. Álvarez López*** (jesus.alvarez@usc.es), Rua Lope Gómez de Marzoa, s/n, Faculdade de Matemáticas, Campus Vida, 15782 Santiago, Coruña, Spain, and **Manuel Calaza**. *Witten's perturbation on strata.*

The main result is a version of Morse inequalities for the minimum and maximum ideal boundary conditions of the de Rham complex on strata of compact Thom-Mather stratifications, endowed with adapted metrics. An adaptation of the analytic method of Witten is used in the proof, as well as certain perturbation of the harmonic oscillator related with the Dunkl harmonic oscillator. (Received September 05, 2012)

1086-58-686 **John Roe*** (john.roe@psu.edu) and **Paul Siegel**. *Sheaves of C^* -algebras and K -homology.* Preliminary report.

The topological properties of Dirac operators are abstracted in the K -homology groups (Brown-Douglas-Fillmore, Kasparov). On the other hand, from a classical perspective the key topological invariant of a Dirac operator is its *symbol*, a section of a certain vector bundle. In this talk we describe a notion of symbol calculus appropriate to abstract K -homology (which makes use of sheaves of C^* -algebras) and give some applications. (Received September 11, 2012)

- 1086-58-875 **E. Cabral Balreira*** (ebalreir@trinity.edu), One Trinity Place, Department of Mathematics, San Antonio, TX 78212. *The Geometry of P-matrices and the Gale-Nikaido Theorem and Applications*. Preliminary report.

An important problem in global injectivity is the result of Gale-Nikaido which states that if the principal minors of the Jacobian matrix of a map defined on a rectangular region of \mathbb{R}^n are positive, then it must be injective. In this talk, we will provide a new geometric condition, called normal cubic assemblage, which can be checked on the boundary of the domain. This condition is satisfied when the Jacobian matrix is a P -matrix and thus it generalizes the Gale-Nikaido Theorem. Applications of these new ideas to competition models in economics and biology will also be shown. (Received September 14, 2012)

- 1086-58-1109 **Yuri A. Kordyukov*** (yurikor@matem.anrb.ru), Institute of Mathematics, Russian Academy of Sciences, 112 Chernyshevsky str., Ufa, 450008, Russia. *Some results on spectral geometry of Riemannian orbifolds*.

We will describe some results on the spectral theory of the Laplace-Beltrami operator on a compact Riemannian orbifold and its connections with dynamics of the geodesic flow. We extend classical results on quantum ergodicity due to Shnirelman, Colin de Verdiere and Zelditch to orbifolds, proving that the ergodicity of the geodesic flow on a compact Riemannian orbifold implies quantum ergodicity for the Laplace-Beltrami operator. For the proof of this theorem, we state two results, which maybe of independent interest. The first result is the local Weyl law for elliptic operators on orbifolds. The second result is a Egorov type theorem for orbifolds. To provide examples of ergodic geodesic flows on orbifolds, we prove the orbifold version of a classical result by Anosov, saying that the geodesic flow on a compact Riemannian orbifold of negative sectional curvature is ergodic. Finally, we will discuss some aspects of noncommutative spectral geometry of orbifolds. (Received September 19, 2012)

- 1086-58-1236 **Paul Loya*** (loya@math.binghamton.edu) and **Klaus Kirsten**. *Casimir's surgery problem*. Preliminary report.

In a very short 1948 paper, Hendrik Casimir published a surprising result using “analytic surgery” for manifolds with corners (specifically a solid three-dimensional box, which is a manifold with corners of codimension three). In previous work, Klaus Kirsten and I derived a Casimir-type surgery formula in the case of smooth manifolds; this formula unfortunately does not apply to Casimir's original situation. However, in this talk, joint with Kirsten, I will present Casimir's surgery formula in full generality for manifolds with corners of any codimension. This in particular applies to Casimir's original situation and from our formula we can explain the origin and meaning of the mysterious constants that appear in Casimir's original formula. (Received September 20, 2012)

- 1086-58-1650 **Ambar Niel Sengupta*** (sengupta@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Geometry and Functional Integrals over Path Spaces*. Preliminary report.

The traditional notion of connections on principal bundles can be extended to parallel-translation on a certain generalization of bundles over spaces of paths. These new structures involve two, or more, gauge groups rather than one. In this talk we will describe these geometric ideas and discuss functional integrals related to these structures. (Received September 23, 2012)

- 1086-58-1716 **Christian Bär*** (baer@math.uni-potsdam.de), Univ. of Potsdam, Inst. f. Mathematics, Am Neuen Palais 10, 14469 Potsdam, Germany. *Renormalized Integrals and a Path Integral Formula for the Heat Kernel on a Manifold*.

We introduce renormalized integrals which generalize conventional measure theoretic integrals. One approximates the integration domain by measure spaces and defines the integral as the limit of integrals over the approximating spaces. This concept is implicitly present in many mathematical contexts such as Cauchy's principal value, the determinant of operators on a Hilbert space and the Fourier transform of an L^p -function.

We use renormalized integrals to define a path integral on manifolds by approximation via geodesic polygons. We derive a path integral formula for the heat kernel of any self-adjoint generalized Laplace operator acting on sections of a vector bundle over a compact Riemannian manifold. (Received September 24, 2012)

- 1086-58-1734 **Nelia Charalambous*** (nelia@ucy.ac.cy) and **Zhiqin Lu**. *The essential spectrum of the Laplacian on open manifolds*. Preliminary report.

The essential spectrum of the Laplacian on functions has been extensively studied. It is known that on hyperbolic space a spectral gap appears, whereas it has been conjectured that on manifolds with uniformly subexponential volume growth and Ricci curvature bounded below the essential spectrum is the nonnegative real line $[0, \infty)$. So far it has only been proved under some strict asymptotic decay assumption on curvature to guarantee uniformly subexponential volume growth. Our goal was to generalize the set of manifolds for which the L^2 spectrum is

the nonnegative real line. In our work with Zhiqin Lu we circumvent Sturm's Theorem, and prove instead a generalization of Weyl's criterion for the essential spectrum. As a result, we will no longer need to assume uniform subexponential volume growth for the manifold. Instead, we will only suppose that Ricci curvature is asymptotically nonnegative in the radial direction. Our condition on curvature only imposes subexponential volume growth at a point. We will prove that on such manifolds the L^2 essential spectrum is $[0, \infty)$. We also use our criterion to compute the essential spectrum of a complete shrinking Ricci soliton and of manifolds that possess an exhaustion function. (Received September 24, 2012)

1086-58-1864 **Lori Beth Ziegelmeier*** (ziegelme@math.colostate.edu), 101 Weber Building, Fort Collins, CO 80523-1874, and **Michael Kirby** and **Chris Peterson**. *Robust Geometric Structure from High Dimensional Data using Sparse LLE*.

The Locally Linear Embedding (LLE) algorithm has proven to be a useful technique for revealing geometric structures in high dimensional data. The basic algorithm reconstructs each data point by a weighted average of its nearest neighbors, and the geometry obtained by these weights captures the lower-dimensional embedding. The embedding reconstruction is highly dependent on the parameter choice of the number of nearest neighbors, i.e., the geometric structure is not robust to parameter selection. We present modifications to the LLE optimization problem that address this shortcoming of standard LLE.

We solve four modified versions of the LLE algorithm using linear and quadratic programming. This is accomplished by altering the objective function by introducing a penalization and considering the error term in the L_1 , L_∞ , and L_2 norms. These new formulations have proven effective at automatically determining nearest neighbors using sparsity of numerical results.

We apply these techniques to biological data sets. We show that the gene expression data from the Duke flu study can be clearly visualized in three dimensions. Further, we will present results concerning blood biomarkers and sepsis diagnosis using data from the Yale Neonate Clinic. (Received September 24, 2012)

1086-58-1898 **Branimir Cacic*** (branimir@caltech.edu), Department of Mathematics, California Institute of Technology, 1200 E California Blvd, MC 253-37, Pasadena, CA 91125. *Dirac-type operators in noncommutative geometry*.

The Gel'fand–Naimark duality establishes a categorical equivalence between compact Hausdorff spaces and commutative unital C^* -algebras, motivating the identification of C^* -algebras as noncommutative topological spaces. More recently, Connes proposed identifying noncommutative manifolds with spectral triples, and has indeed proved a partial analogue of Gel'fand–Naimark, the reconstruction theorem, which guarantees that so-called commutative spectral triples do indeed arise from compact oriented manifolds. We give a brief introduction to the theory of spectral triples from the perspective of the theory of Dirac-type operators, and in particular outline how Dirac-type operators arise in the theory of almost-commutative spectral triples, the spectral triples appearing in applications to theoretical high energy physics. We then show how to refine the reconstruction theorem into a precise noncommutative-geometric characterisation of compact oriented Riemannian manifolds together with Dirac-type operator, and hence obtain a reconstruction theorem for almost-commutative spectral triples. (Received September 24, 2012)

1086-58-1960 **Shuguang Wang*** (wangs@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO MO 65203. *A higher dimensional Donaldson theory for foliated manifolds*.

In 1998 Simon Donaldson and Richard Thomas initiated Gauge Theory for higher dimensional manifolds of special holonomy. In particular they discussed and made several key observations on the possible linearization/Fredholm index theory and perturbations/transversality of the relevant moduli spaces. Since then they and others have followed up the work in more special situations. Going in a different direction, Gang Tian in 2000 introduced a very general anti-self dual equation for any higher dimensional manifolds and proved an important compactification theorem for the moduli space. He also proved that the blow-up locus has a nice calibrated geometric structure and the singularity set is relatively small in terms of Hausdorff measure. In this talk we will propose another Donaldson type theory on higher dimensional manifolds carrying co-dimension 4 foliations. We introduce the foliated anti-self dual equation, which roughly can be treated as a special case of Tian's equation. We prove a complete perturbation/transversality theorem for the moduli space. We also show an improved compactification theorem, which states that the blow-up locus consists of compact leaves and the singularity set is empty. (Received September 24, 2012)

1086-58-2136 **Alexander Gorokhovskiy***, Department of Mathematics, University of Colorado, Boulder, CO 80305, and **Henri Moscovici**. *Higher analytic indices and symbolic index pairing*. Preliminary report.

Higher index theory was started in the work of A. Connes and H. Moscovici on the Novikov conjecture. The goal of my talk is to reinterpret their theorem, extend the definition of higher indices to new situations, and to describe a theorem computing them in topological terms. (Received September 24, 2012)

1086-58-2704 **Arthur E Fischer*** (aef@ucsc.edu), Department of Mathematics, University of California, Santa Cruz, CA 95064. *Conformal Ricci Flow on the Teichmüller Space of Conformal Structures on a compact n -dimensional manifold, $n \geq 3$.*

We introduce a variation of the classical Ricci flow equation that modifies the volume constraint of that equation to a scalar curvature constraint. The resulting equations are named the **conformal Ricci flow equations** because of the role that conformal geometry plays in constraining the scalar curvature. These new equations are given by

$$\begin{aligned} \frac{\partial g}{\partial t} + 2(\text{Ric}(g) + \frac{1}{n}g) &= -pg \\ R(g) &= -1 \end{aligned}$$

for a dynamically evolving metric g and a non-dynamical scalar field $p \geq 0$, named the **conformal pressure**. The conformal pressure serves as a Lagrange multiplier to conformally deform the flow so as to maintain the scalar curvature constraint. The conformal Ricci flow equations are analogous to the **Navier-Stokes equations** of fluid mechanics

$$\begin{aligned} \frac{\partial v}{\partial t} + \nabla_v v + \nu \Delta v &= -\text{grad } p \\ \text{div } v &= 0 \end{aligned}$$

The conformal Ricci flow equations can be thought of as a Navier-Stokes equation for the metric g , just as the classical Ricci flow equation can be thought of as a heat equation for g . Properties of the conformal Ricci flow equations and their interpretation as a flow on the Teichmüller space of conformal structures are discussed. (Received September 26, 2012)

1086-58-2850 **Igor Prokhorenkov*** (i.prokhorenkov@tcu.edu) and **Ken Richardson** (k.richardson@tcu.edu). *Transversal Witten deformations on Riemannian foliations*.

We describe how to compute an index of a transversal Dirac operator D_{tr} by perturbing the operator with a geometric bundle map Z and considering the semiclassical limit of $D_{tr} + sZ$ as $s \rightarrow \infty$. In a special case of a Riemannian foliation, the answer is expressed in terms of local data at singular leaf closures of Z . (Received September 25, 2012)

60 ► Probability theory and stochastic processes

1086-60-9 **Gerard Ben Arous*** (gba1@nyu.edu), 251 Mercer Street, New York, NY 10012. *Complexity of random functions of many variables*.

Can one count the number of critical points for random smooth functions of many variables? How complex is a typical random smooth function? How complex is the topology of its level sets? We study here the simplest case of smooth Gaussian random functions defined on the sphere in high dimensions. We show that such a randomly chosen smooth function is very complex, i.e. that its number of critical points of given index is exponentially large. We also study the topology of the level sets of these functions, and give sharp estimates of their Euler characteristic. This study, which is a joint work with Tuca Auffinger (Chicago) and partly with Jiri Cerny (Vienna), relies rather surprisingly on Random Matrix Theory. The main motivation comes from the study of energy landscapes for notoriously hard problems of statistical mechanics of disordered media, i.e. general spherical spin-glasses. I will detail the interesting picture we get for the complexity of these random Hamiltonians, and for the bottom of the energy landscape. We also propose a new invariant for the possible transition between two very different classes of complexity. (Received September 20, 2012)

1086-60-15 **Alice Guionnet***, Ecole Normale Supérieure de Lyon, Lyon, France. *Free probability, Random matrices and map enumeration, I*.

Free probability is a theory initiated by D. Voiculescu in the eighties that studies non-commutative random variables. It is equipped with a notion of freeness, which is related with free products, and which plays the same role as independence in standard probability. Free probability is a natural framework to study random

matrices at the limit where their size goes to infinity. Conversely, random matrices provide natural tools and concepts in free probability. In this talk, we will introduce basic concepts in free probability and show how to construct a wide variety of non-commutative laws by using random matrices. We will also describe some uses of free probability theory. (Received April 10, 2012)

1086-60-27 **Mark Burgin**, Los Angeles, CA 90095, and **Gunter Meissner*** (meissner@hawaii.edu), Honolulu, HI. *Mathematical Tools for Modeling Negative Interest Rates*. Preliminary report. Standard mathematical models in finance give only positive interest rates. At the same time, negative nominal interest rates have occurred several times in financial practice, as it happened in the 2008/2009 global financial crisis, in Switzerland in the 1970s or in Japan in 2003. As it is demonstrated in (Burgin, M. and Meissner, G. Negative Probabilities in Modeling Random Financial Processes, *Integration*, v. 2, No. 3, 2010, pp. 305 - 322), negative probabilities allow economists to overcome some shortcomings of the standard models. However, some problems demand other types of probabilistic tools. In this work, a mathematical theory of inflated probability, which may take larger than one values, is developed and its applications to financial problems in the context of the Black-Scholes-Merton framework are explained. Different properties of inflated probability are obtained. Some of these properties are similar to properties of the classical probability, while other properties are essentially different. (Received May 23, 2012)

1086-60-78 **Andrew Papanicolaou***, Sherrerd Hall, Charlton st, Princeton, NJ 08544. *Asymptotic Expansion of Regime-Switching Models for Consistent Pricing of VIX and S&P500 Derivatives*. Stochastic volatility models explain some of the heavy-tailedness observed in Black-Scholes implied volatility smile/skew. The new VIX methodology is appealing because it is model-free, but the matter of the VIX's heavy-tailedness arises from the skew observed in the implied volatility of VIX options. A unified volatility model for both equity and VIX derivatives can be developed by making well-known volatility models more sophisticated with the addition of jumps and stochastic parameters, and such additions will provide some new explanatory power for addressing the heavy-tailedness issues. (Received July 07, 2012)

1086-60-81 **Xueying Wang*** (xueying@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77840, and **Raju Gautam, Pablo J. Pinedo, Linda J. S. Allen and Renata Ivanek**. *A stochastic model for transmission, extinction and outbreak of Escherichia coli O157:H7 in cattle as affected by ambient temperature and pathogen cleaning practices*. This study proposes a stochastic-differential equation model as an approximation to a Markov jump process model, using Escherichia coli O157:H7 in cattle as a model system. In the model, the host population infection dynamics are described using the standard susceptible-infected-susceptible framework, and the E. coli O157:H7 population in the environment is represented by an additional variable. The backward Kolmogorov equations that determine the probability distribution and the expectation of the first passage time are rigorously derived in a general setting. The outbreak and apparent extinction of infection are investigated by numerically solving the Kolmogorov equations for the probability density function of the associated process and the expectation of the associated stopping time. The results provide insight into E. coli O157:H7 transmission and apparent extinction, and suggest ways for controlling the spread of infection in a cattle herd. Specifically, this study highlights the importance of ambient temperature and sanitation, especially during summer. (Received July 09, 2012)

1086-60-102 **Phillip J Monin*** (pmonin@math.utexas.edu), University of Texas at Austin, Department of Mathematics, 1 University Station, C1200, Austin, TX 78705. *On a dynamic extension of the method of the Distribution Builder*. Sharpe, Johnson, et al. developed a computer program called the Distribution Builder whose output is effectively an investor's desired probability distribution for future wealth. In a single-period model, they show how this distribution can be used to infer the investor's implied preferences for risk. We extend their results to continuous time; namely, we show how an investor's choice of distribution for future wealth at some point within a given investment horizon determines the investor's risk preferences and optimal investment policies throughout. We provide various examples and consider some extensions. (Received July 17, 2012)

- 1086-60-273 **Mark Burgin***, UCLA, Los Angeles, CA 90095, and **Alan C. Krinik**, California State Polytechnic University, Pomona, CA 91768. *What to do with Random Variables that don't have Expectations*. Preliminary report.

It is well known that the expected value does not exist for some important distributions, such as the Cauchy distribution. To overcome this limitation, we extend the concept of expectation to the concept of hyperexpectation. Hyperexpectation is constructed as a hyperintegral of a random variable instead of the integral used for conventional expectations. This allows us to correspond hyperexpectation to all random variables in such a way that when a random variable has the expected value, its hyperexpectation coincides with this expected value. In addition, we characterize hyperexpectation by axioms, building hyperprobabilities (cf. Burgin, M. and Krinik, A. Introduction to Conditional Hyperprobabilities, Integration: Mathematical Theory and Applications, 2(3), 2011, 285-304) based on hyperexpectations and demonstrating that probabilities emerge from expectations in this approach. Properties of hyperexpectation and hyperprobabilities are obtained. It is also proved that the conventional expectation of random variables is a special case of hyperexpectation, demonstrating that the concept of hyperexpectation is a natural generalization of the concept of expectation and this generalization extends efficiency and applicability of probability theory. (Received August 15, 2012)

- 1086-60-289 **Nikolai N. Leonenko**, **Mark M. Meerschaert** and **Alla Sikorskii*** (sikorska@stt.msu.edu), Department of Statistics and Probability, Michigan State University, East Lansing, MI 48824. *Fractional Pearson Diffusion*.

Pearson diffusions are governed by diffusion equations with polynomial coefficients. The Pearson diffusion equation governs several useful classes of Markov processes, including the Ornstein-Uhlenbeck process and the Cox-Ingersoll-Ross process, which are useful in finance. Fractional Pearson diffusions are governed by the corresponding time-fractional diffusion equation, where the first time derivative is replaced by a Caputo fractional derivative of order $0 < \alpha < 1$. Explicit strong solutions are developed, using spectral methods. To our knowledge, these are the first explicit solutions of time-fractional diffusions with variable coefficients available in the literature. Stochastic solutions are then obtained, using a non-Markovian time change involving the inverse stable subordinator. The solutions are useful for modeling sub-diffusive phenomena, caused by particle sticking and trapping. (Received August 15, 2012)

- 1086-60-312 **Gerardo Rubino*** (gerardo.rubino@inria.fr), INRIA Rennes, Campus de Beaulieu, 35042 Rennes, France. *Quality of Monte Carlo rare event analyzers*.

For complex systems, simulation is in general the only possible tool for their quantitative analysis, either for studying their performances or their dependability properties. Simulation is powerful, but it has its own drawbacks, and one of the main ones is the difficulties in analyzing rare events. When the event of interest is rare, standard simulation simply fails. This led to the development of whole families of specialized estimators, for different types of metrics, among which we can underline Importance Sampling and Splitting methods. This also led to the development of mathematical tools for capturing the right properties of an estimator in this context, in order to evaluate its quality in general (its efficiency, its robustness, etc.). This talk explores these issues, underlines the hard open points and proposes some research perspectives. (Received August 20, 2012)

- 1086-60-318 **Indranil SenGupta*** (indranil.sengupta@ndsu.edu), Department of Mathematics, North Dakota State University, Fargo, ND 58108. *Jump in financial market and estimation of earthquake- a similar analysis*.

In this work we study scale invariant functions and stochastic Lévy models and we apply them to Geophysical data. We show that a pattern arises from the scale invariance property and Lévy flight models that may be used to estimate parameters related to some major event - major earthquake. We relate this to some results in finance. Surprisingly both Lévy flight and scale invariance methods give reasonable estimate for the *crash*. *Crash* in geophysical data will be interpreted as an estimation of earthquake. For financial market it will be interpreted as some major jump. (Received August 20, 2012)

- 1086-60-338 **Christoph Frei*** (cfrei@ualberta.ca), University of Alberta, Mathematical and Statistical Sciences, Edmonton, Alberta T6G 2G1, Canada, and **Nicholas Westray**. *Optimal execution of a VWAP order: a stochastic control approach*.

We consider the optimal liquidation of a position of stock (long or short) where trading has a temporary market impact on the price. The aim is to minimize both the mean and variance of the order slippage with respect to a benchmark given by the market VWAP (volume weighted average price). In this setting, we introduce a new model for the relative volume curve which allows simultaneously for accurate data fit, economic justification and mathematical tractability. Tackling the resulting optimization problem using a stochastic control approach, we

derive and solve the corresponding Hamilton-Jacobi-Bellman equation to give an explicit characterization of the optimal trading rate and liquidation trajectory. (Received August 22, 2012)

1086-60-381 **Yipeng Yang*** (yangyip@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Multi-dimensional Stochastic Singular Control Via Dynkin Game and Dirichlet Form*. Preliminary report.

The traditional difficulty about stochastic singular control is to characterize the existence and regularities of the value function and the optimal control policy. In this paper, a multi-dimensional singular control problem is considered. We found the optimal value function and the optimal control policy of this problem via Dynkin game, whose solution is given by the saddle point of the cost function. The existence and uniqueness of the solution to this Dynkin game are proved through an associated variational inequality problem involving Dirichlet form, and the non-existence of exceptional set in higher dimensional space is proved using the absolute continuity of the probability transition function of the underlying process. We also showed that the integrated form of the value function of the Dynkin game yields the value function of the singular control problem. As a consequence, the properties of the value function of this Dynkin game implies the smoothness of the value function of the stochastic singular control problem. In this way, we are able to show the existence of a classical solution to this multi-dimensional singular control problem, which was traditionally solved in the sense of viscosity solutions. (Received August 27, 2012)

1086-60-385 **Marc A Harper*** (marcharper@ucla.edu). *Inferring Fitness in Finite, Variably-Sized, Evolving, and Dynamically-Structured Populations*. Preliminary report.

Fitness is a critical concept in evolutionary biology, yet unlike many observables in the sciences, such as electrical current, fitness is a hidden quantity that cannot be measured directly. In this talk I will show how to apply Bayesian inference to estimate fitness in finite, variably-sized, evolving, and dynamically-structured populations described by stochastic processes on graphs similar to and including the Moran process. We will see that fitness is inferable from the population trajectory and how population structure affects the inference of fitness (along with videos of inference unfolding on simulated stochastic trajectories), and we will discuss new families of probability distributions developed for this analysis. Time permitting, we will discuss the impact of sampling, how to estimate the amount of information gained from observing a birth event, and computational challenges encountered in this work. (Received August 30, 2012)

1086-60-435 **Tim Leung*** (t12497@columbia.edu) and **Xin Li** (x12206@columbia.edu). *An Optimal Timing Approach to Mean-Reversion Trading*.

This paper studies the optimal entry and exit timing for trading under mean reversion. This leads to the formulation and analysis of a number of double optimal stopping problems with constraints under time-homogeneous diffusions, including Ornstein-Uhlenbeck, exponential Ornstein-Uhlenbeck, and Cox-Ingersoll-Ross price processes. We rigorously derive the optimal price levels for entry and exit respectively, and examine their dependence on various model parameters such as mean-reversion level and transaction cost. We further analyze the trading problem under a minimal holding period, as well as stop-loss and risk penalty. Numerical results are provided to illustrate the optimal strategies. (Received September 24, 2012)

1086-60-483 **Radka Pickova*** (radka@stat.columbia.edu), Room 1005 SSW, MC 4690, 1255 Amsterdam Avenue, New York, NY 10027. *Volatility-Stabilized Markets*. Preliminary report.

We consider models which generalize the Volatility-Stabilized Markets introduced in Fernholz and Karatzas (2005). We show how to construct a weak solution of the underlying system of stochastic differential equations, express the solution in terms of time changed squared-Bessel processes, and argue that this solution is unique in distribution. Moreover, we discuss sufficient conditions for existence of strong solution, and show that strong relative arbitrage opportunities exist in these markets. (Received September 04, 2012)

1086-60-537 **Guangliang Zhao*** (ea4628@wayne.edu). *Regularization and Stabilization of Hybrid Diffusion System*.

This presentation focuses on switching diffusions that are modulated by a continuous-time Markov chain. The dynamics are represented by Markovian switching diffusions. The goal is to stabilize the systems. The difficulty is that the systems grow much faster than the allowable rates in the classical stochastic differential equation setup, and as a result, the underlying systems may be exploded in finite time. To overcome the difficulties, the main efforts are to develop feedback controls so that we can first extend the local solutions to global solutions and then stabilize the resulting systems. The feedback controls are, in fact, Brownian type of perturbations. After establishing the regularity, proving the stability of the resulting systems, obtaining tightness of the solutions,

and providing sufficient conditions for almost sure stability, we present numerical experiments to illustrate the main results. [This is a joint work with George Yin and Fuke Wu.] (Received September 06, 2012)

1086-60-539 **Brian M. Whitehead*** (whiteheadb@easternct.edu). *Path Properties of Jump Processes having Nondegenerate Jumping Kernels.*

We consider a family of jump processes in euclidean space. Several interesting results have been shown in the case where the jump kernels of the processes are closely related to those of a stable processes. Here we consider a significantly more general version of the jump kernel, and show that some properties, including a support theorem, can be extended and shown to be true in this case as well. (Received September 06, 2012)

1086-60-622 **Hasanjan Sayit*** (hs7@wpi.edu). *Absence of arbitrage in a general framework.*

Cheridito (Finance Stoch. 7: 533-553, 2003) studies a financial market that consists of a money market account and a risky asset driven by a fractional Brownian motion (fBm). It is shown that arbitrage possibilities in such markets can be excluded by suitably restricting the class of allowable trading strategies. In this note, we show an analogous result in a multi-asset market where the discounted risky asset prices follow more general non-semimartingale models. In our framework, investors are allowed to trade between a risk-free asset and multiple risky assets by following simple trading strategies that require a minimal deterministic waiting time between any two trading dates. We present a condition on the discounted risky asset prices that guarantee absence of arbitrage in this setting. We give examples that satisfy our condition and study its invariance under certain transformations. (Received September 09, 2012)

1086-60-722 **G. Yin** and **Yousef A. Talafha*** (ee7542@wayne.edu), Department of Mathematics, Wayne State University, 656 W Kirby, 1256 FAB, Detroit, MI 48202, and **F. Xi**. *Randomly Switching Stochastic Liénard Equations with Two-time Scales.*

This work is concerned with randomly switching stochastic Lienard equations. Our study focuses on complex systems with both continuous and discrete states. The continuous component is a solution of a stochastic Lienard equation and the discrete component is a Markov chain with a finite state space. Using a two-time-scale formulation, we show that under some conditions the stochastic Lienard equation converges weakly to a limit process using a martingale problem formulation. Finally, Simulation results are presented. (Received September 11, 2012)

1086-60-756 **Yu-Jui Huang*** (jayhuang@umich.edu) and **Erhan Bayraktar**. *Robust Maximization of Asymptotic Growth under Covariance Uncertainty.*

This paper resolves a question proposed in Kardaras and Robertson (2012): how to invest in a robust growth-optimal way in a market where precise knowledge of the covariance structure of the underlying assets is unavailable. Among an appropriate class of admissible covariance structures, we characterize the optimal trading strategy in terms of a generalized version of the principal eigenvalue of a fully nonlinear elliptic operator and its associated eigenfunction, by slightly restricting the collection of non-dominated probability measures. (Received September 12, 2012)

1086-60-799 **Maxim Bichuch*** (mbichuch@princeton.edu) and **Stephan Sturm** (ss Sturm@wpi.edu). *Portfolio Optimization under Convex Incentive Schemes.*

We consider a utility maximization problem of terminal wealth from the point of view of a portfolio manager paid by convex incentives. Even though the manager's utility function is concave, the result is a non-concave optimization problem that does not fit into the classical portfolio optimization theory. Using duality theory, we prove existence and uniqueness of the optimal wealth in general (incomplete) markets. (Received September 12, 2012)

1086-60-805 **In-Suk Wee*** (iswee@korea.ac.kr), 1 Anam-dong, Sungbuk-ku, Seoul, 136-701, South Korea, and **Bara Kim** (bara@korea.ac.kr), 1 Anam-dong, Sungbuk-ku, 136-701, South Korea. *Pricing of geometric Asian options under Heston's stochastic volatility model.*

In this work, we assume that the underlying asset price follows Heston's stochastic volatility model, and derive explicit solutions for the prices of the geometric Asian options with fixed and floating strikes. Our approach has to deal with derivation of the generalized joint Fourier transform of a square root process and of three different weighted integrals of the square root process with constant, linear and quadratic weights. We also provide numerical implementation results of the complicated expressions and present computational stability and efficiency of our method. (Received September 13, 2012)

1086-60-810 **Barbara Margolius*** (b.margolius@csuohio.edu), OH. *In defense of the much maligned Bessel function formula for transition probabilities for the single server queue.*

The single server queue with Poisson arrivals and exponential service is generally considered the simplest interesting queue. The formula for the transient probabilities for the number in queue that is given in many queueing texts involves modified Bessel functions. In their 1962 text, Cox and Smith write:

The solution is, however, far from convenient; when we consider that it originates from one of the very simplest queueing systems, the difficulty of obtaining general solutions in more complicated cases will be apparent.

Reviews of the formula haven't improved much over the years. Over the ensuing decades it has been called: "disheartening", "ugly", "alarming", "somewhat daunting" and "difficult to evaluate or interpret". The most recent of the quotes comes from a 2009 text, while the others span the intervening decades. In this talk, I will discuss how to interpret, evaluate, and generalize this formula beginning with Champernowne's proof involving the random walk. (Received September 13, 2012)

1086-60-836 **Natasha Blitvić*** (natasha.blitvic@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *The (q, t) -Gaussian Process.*

Fock spaces, used in quantum mechanics to represent collections of quantum states with a variable number of particles, are a natural setting for non-commutative probability. In addition to the bosonic and fermionic Fock spaces of classical and quantum probability, notable examples include the full Boltzmann Fock space (Voiculescu's free probability) and the q -Fock space (q -deformed probability of Bożejko and Speicher). This talk describes a new type of Fock space, namely the (q, t) -Fock space, that generalizes the aforementioned constructions and gives rise to a rich two-parameter family of non-commutative probability spaces. We will particularly focus on the properties and the role of the (q, t) -Gaussian measure, the orthogonalizing measure of the deformed Hermite orthogonal polynomial sequence

$$xH_n(x) = H_{n+1}(x) + [n]_{q,t} H_{n-1}(x),$$

with $H_0(x) = 1$, $H_1(x) = x$, and $[n]_{q,t} = (t^n - q^n)/(t - q)$. We will also discuss the combinatorics underlying the (q, t) -Fock space construction and the probabilistic significance of the $q = 0$ specialization, which gives rise to the generalized Rogers-Ramanujan continued fraction, the quantum Airy function of Ismail, and the deformed Catalan numbers of Carlitz and Riordan. (Received September 16, 2012)

1086-60-947 **Mykhaylo Shkolnikov***, 367 Evans Hall, University of California, Berkeley, Berkeley, CA 94720. *Brownian particle systems as models of large equity markets.*

We will discuss some new developments in stochastic portfolio theory. More precisely, we will consider a new class of models for large equity markets, which are equally capable of explaining the macroscopic structure of the markets as the original first-order models of Fernholz and Karatzas; in addition, the new models also explain some of the microscopic properties of equity markets, such as the discrepancy between the leakage of capital at the top ranks and in the bulk of the market. In addition, we describe a method for the simulation of leakages within this framework via an approximation by discrete interacting particle systems. Based on joint work with Ioannis Karatzas and Soumik Pal. (Received September 17, 2012)

1086-60-964 **Cristian Tomasetti*** (cristian@jimmy.harvard.edu), 450 Brookline Ave, Mail Location: CLS11007, Boston, MA 02215, and **Bert Vogelstein** and **Giovanni Parmigiani**. *Stochastic modeling of the accumulation of somatic mutations in cancer.*

One useful approach for better understanding the process of cancer evolution is given by the integration of mathematical modeling with the ever growing amount of sequencing data of cancer tissues.

While it has been hypothesized that some of the somatic mutations found in tumors may occur prior to tumor initiation, there is little experimental or conceptual data on this topic. To gain insights into this fundamental issue, we formulated a new mathematical model for the evolution of somatic mutations in which all relevant phases of a tissue's history are considered. The model provides a way to estimate the in-vivo tissue-specific somatic mutation rates in normal tissues directly from the sequencing data of tumors. The model also makes novel predictions, validated by our empirical findings, on the expected number of somatic mutations found in tumors of self-renewing tissues. Furthermore, a general principle for improving the detection of driver mutations by reducing the amount of "noise" caused by the passenger mutations will be introduced.

Our results have substantial implications for the interpretation of the large number of genome-wide cancer studies now being undertaken. (Received September 17, 2012)

- 1086-60-1048 **Scott A Hottovy*** (shottovy@math.arizona.edu). *Smoluchowski-Kramers Approximation for Multidimensional systems.*

A small particle with diameter on the order of nano-meters to micrometers undergoes random motion when in a fluid. The motion is described by a stochastic Newton equation, using stochastic differential equations (SDE), relating acceleration with the forces acting on the particle. Experimentally, it is very difficult to measure the instantaneous velocity of the particle. Therefore, valid approximations to the SDE are useful for applications. One such approximation is the small mass, also called the Smoluchowski-Kramers, approximation. I will describe a new way to identify and prove this limit for systems of arbitrary dimension and give applications of this theorem to systems of experimental interest. (Received September 18, 2012)

- 1086-60-1057 **John C. Wierman*** (wierman@jhu.edu), Johns Hopkins University, Dept. of Applied Mathematics & Statistics, Baltimore, MD 21218. *Computing percolation threshold bounds using the substitution method without a reference lattice.* Preliminary report.

In percolation theory, an infinite random lattice graph model is studied. A fundamental quantity is the percolation threshold, often interpreted as a phase transition point, above which infinite clusters exist. Past applications of the substitution method derived rigorous upper and lower bounds for the percolation threshold of a lattice graph by comparison with a percolation model on an exactly-solved lattice graph. For a class of planar lattice graphs, an approach that does not require a reference lattice will be presented. (Received September 18, 2012)

- 1086-60-1066 **Jef K Caers*** (jcaers@stanford.edu), Energy Resources Engineering, Stanford University, CA 94305-2220. *Generalized Sensitivity Analysis for Managing Uncertainty in Complex Earth Systems.*

In this presentation we develop a new generalized sensitivity analysis typically applicable in the engineering of complex Earth systems. Applications are the engineering of groundwater, oil and gas reservoirs, CO2 sequestration, mineral extraction, climate modeling etc. Most critical in such modeling is to find which model parameters (including combinations) are impacting the decision variables most. Many parameters need to be considered in all aspects (geophysical, geological, geochemical) of the Earth model. Some parameters are continuous; others discrete, other have no intrinsic value and are scenario-based. In this paper we develop a method of regional sensitivity analysis that classifies the response variables into a limited set of discrete classes. Then we start from the following principle: if the parameter frequency distribution is the same in each class, then that means there is no sensitivity, while the deviation from this null-hypothesis would indicate sensitivity. Based on this simple idea we develop a new measure of sensitivity that is general, as well as develop ways to understand multi-way interaction between such parameter based on class-conditional distribution models. We illustrate our techniques in a real case study of a West Africa off-shore oil reservoir. (Received September 18, 2012)

- 1086-60-1074 **Jennifer M Switkes*** (jmswitkes@ccsupomona.edu), 3801 W. Temple Ave., Pomona, CA 91768. *Averaging the Averages of Perceived Highway Speed.*

We consider the effects of averaging multiple drivers' perceptions of the average speed of traffic on a highway. This work builds on a previous model based on a single driver's perception of the average speed of traffic on a highway, using a continuous probability distribution of car speeds. We examine the resulting often-biased perceptions of the average speed of highway traffic, and we look at attempts to accurately find the average highway speed. (Received September 18, 2012)

- 1086-60-1080 **Thomas W Seaquist*** (thomas.seaquist@mavs.uta.edu). *Optimal Stopping for Markov Modulated Diffusions.* Preliminary report.

Accurate pricing of stock options is critical to avoiding arbitrage. Traditional models used in option pricing are limited to a constant drift and volatility of a stock process X_t . In this paper, a Markov modulated Ito-Diffusion is developed to describe a stock that switches drift and volatility through a finite state Markov chain ξ_t . The valuation of a infinite horizon American put option is described by the general optimal stopping problem $V(x, i) = \sup_{\tau} E^{(x, i)} \left[e^{\int_0^{\tau} -r(\xi_s) ds} \phi(X_{\tau}) \right]$. This optimal stopping problem is solved by using a logarithmic transformation and drawing a connection to a set of PDE's similar to the traditional Black-Scholes equations. (Received September 18, 2012)

- 1086-60-1112 **Qi Fu*** (umacfuqi@gmail.com), Faculty of Business Administration, University of Macau, Macau, 999078, Peoples Rep of China. *Valuing Callable Bonds Based on Monte Carlo Simulation Techniques with Least-Squares Approach.*

A callable bond is a bond that allows the issuer to buy back the bonds from the bond holders at pre-specified prices on the pre-specified call dates. Therefore, a callable bond is a straight bond embedded with a call of European option (a single call date) or Bermudan option (several call dates). However, this option is an integral

part of a bond, and cannot be traded alone, and hence, its prices cannot be observed. Thus, the callable bond pricing must be involved in the pricing problem of the corresponding option.

In this paper, a Monte Carlo method via least-squares approach, which is based on some new simulation techniques proposed recently, is presented to numerically price the callable bond with several call dates and notice under the Cox-Ingersoll-Ross (CIR) interest rate model. The numerical experiments show that this method works well for callable bond under the CIR interest rate model and can value break-even interest rate more precisely than the pure Monte Carlo method proposed before. (Received September 19, 2012)

1086-60-1114 **Norio Konno*** (konno@ynu.ac.jp), 79-5 Tokiwadai, Hodogaya, Yokohama, 240-8501, Japan. *Stationary Measures and Time-Averaged Limit Measures of Quantum Walks.*

The quantum walk (QW) can be considered as a counterpart of the classical random walk (RW), see [1,2], for example. In contrast with the diffusive spreading of the RW, the QW has two specific properties, i.e., localization and ballistic spreading. In this talk, I consider stationary measures and time-averaged limit measures of QWs [3,4]. References: [1] N. Konno (2008), Quantum walks, Lecture Notes in Mathematics, Vol.1954, Springer, pp.309-452. [2] S. E. Venegas-Andraca (2012), Quantum walks: a comprehensive review, Quantum Information Processing (in press), arXiv:1201.4780. [3] N. Konno, T. Luczak, and E. Segawa (2011), Limit measures of inhomogeneous discrete-time quantum walks in one dimension, Quantum Information Processing (in press), arXiv:1107.4462. [4] C. Liu and N. Petulante (2011), On limiting distributions of quantum Markov chains, Article ID 740816, International Journal of Mathematics and Mathematical Sciences. (Received September 19, 2012)

1086-60-1124 **Yumin Wang*** (yumin@siu.edu), 2006 Woodriver Dr. #19, Carbondale, IL 62901. *Efficient Hedging For Guaranteed minimum death benefits.* Preliminary report.

The idea of efficient hedging has been introduced by Föllmer and Leukert. They look for hedges which are efficient with respect to the partial ordering defined by the average of the capital injected weighted by the loss function and the initial capital. Guaranteed minimum death benefits (GMDBs) are present in various annuity contracts, and act as a form of portfolio insurance. They cannot be perfectly hedged due to the mortality component, except in the limit as the number of contracts becomes infinitely large. In this article, we use the efficient hedging methodology to derive pricing formula for these products under various assumptions. (Received September 19, 2012)

1086-60-1127 **Hyunchul Park*** (hpark48@illinois.edu), 2109 W.White st Apt200, Champaign, IL 61821, and **Panki Kim** and **Renming Song**. *Sharp estimates on the Green functions of perturbations of subordinate Brownian motions in bounded κ -fat open sets.*

In this talk we study perturbations of a large class of subordinate Brownian motions in bounded κ -fat open sets, which include bounded John domains. Suppose that X is such a subordinate Brownian motion and that J is the Lévy density of X . The main result of this paper implies, in particular, that if Y is a symmetric Lévy process with Lévy density J^Y satisfying $|J^Y(x) - J(x)| \leq c \max\{|x|^{-d+\rho}, 1\}$ for some $c > 0, \rho \in (0, d)$, then for any bounded John domain D the Green function G_D^Y of Y in D is comparable to the Green function G_D of X in D . One of the main tools of this paper is the drift transform introduced in [?]. To apply the drift transform, we first establish a generalized 3G theorem for X . (Received September 19, 2012)

1086-60-1166 **Wanwan Huang*** (bsbhuang8527@gmail.com), 700 W. Virginia ST, APT 118, Tallahassee, FL 32304. *Option Valuation Using Fast Fourier Transform Method under the CAM Stochastic Volatility Model.* Preliminary report.

In this paper we study the distribution of Coupled-Additive Multiple Noises (CAM) stochastic volatility model using a fast Fourier transform (FFT) method. The technique in Heston's paper is applied to derive a closed-form solution for the characteristic function of this model. The characteristic function is in the form

$$\phi(x, y, T; u) = \exp\{C(T - t; u) + D(T - t; u)y + iux\},$$

where x is the spot asset return, which is $\log(S_t)$, y is the diffusion process which drives the volatility of underlying asset S_t , $T - t$ represents the time to maturity of the European call option, and $C(T - t; u)$ and $D(T - t; u)$ are two time related terms which can be solved from two ordinary differential equations. The ordinary differential equations are from the Fokker-Planck forward equation. The curve of the characteristic function under certain initial conditions has been plotted. Based on this function, the probability density of x was computed using the FFT method. The plot of the distribution is skewed with a fat left tail. European call option prices are computed using the modified call price FFT method mentioned in Carr and Madan's paper. (Received September 19, 2012)

- 1086-60-1274 **Edward J. Allen*** (edward.allen@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *A Stochastic Analysis Of Power Doubling Time For A Subcritical System.*

For a subcritical nuclear reactor, power doubling time is a theoretical and practical concept, useful for example, in certain reactor start-up operational procedures. Suppose that the control rods are positioned so that the reactor is subcritical and the reactor power, originating from decay of radioactive material in the core, is in equilibrium. Now suppose that the control rods are withdrawn a certain distance so that the reactor stays subcritical but the new equilibrium power level is twice the original level. The time it takes for the power to reach the new equilibrium level is the doubling time. Although power doubling is a widely recognized phenomenon, it is identified in the present investigation as a stochastic first-passage time problem. Using stochastic point kinetics equations that model the dynamic behavior of a nuclear reactor, relations for the mean doubling time and the standard deviation in doubling time are derived. It is shown that the power doubling time for a subcritical system is independent of whether the system is fast or thermal, weakly depends on source strength, and is approximately proportional to the inverse of the reactivity for small negative values of the reactivity. (Received September 20, 2012)

- 1086-60-1283 **G. S. Ladde**, Department of Mathematics, University of South Florida, Tampa, FL, and **M. Sambandham*** (msambandham@yahoo.com), Department of Mathematics, Morehouse College, Atlanta, GA 30314. *Convergence and Stability Analysis of Stochastic Large-Scale Approximation Scheme.* Preliminary report.

Variational comparison theorems for a class of stochastic hybrid systems are developed. These comparison results are applied to study the convergence and relative stability analysis of stochastic large-scale approximation schemes for an initial value problem in the framework of the stochastic hybrid system. Suitable examples are given to illustrate the results. (Received September 20, 2012)

- 1086-60-1284 **Jinqiao Duan*** (jduan@ipam.ucla.edu), Univ of California, 460 Portola Plaza, Los Angeles, CA 90095-7121. *A Glimpse of Non-Gaussian Stochastic Dynamics.*

Dynamical systems arising in biological, physical and chemical sciences are often subject to random influences, which are also known as "noise". Stochastic differential equations are appropriate models for some of these systems. The noise in these stochastic differential equations may be Gaussian or non-Gaussian in nature. Non-Gaussianity of the noise manifests as nonlocality at a macroscopic level. In addition, randomness may have delicate, or even profound, impact on the overall evolution of dynamical systems. The speaker will present an overview of some available theoretical and numerical techniques for analyzing stochastic dynamical systems, including escape probability, mean exit time, invariant manifolds, bifurcation and quantifying the impact of uncertainty. The differences in dynamics under Gaussian and non-Gaussian noises are highlighted, in the context of a tumor growth system. (Received September 20, 2012)

- 1086-60-1341 **Santanu Chakraborty*** (schakraborty@utpa.edu), Associate Professor, Department of Mathematics, UTPA, 1201 West University Drive, Edinburg, TX 78539, and **Arunava Mukherjee** (arunava.mukherjee@gmail.com), Professor, Department of Mathematics, UTPA, 1201 West University Drive, Edinburg, TX 78539. *Limit Distributions of Random Walks on Stochastic Matrices.* Preliminary report.

The limit distribution of the sequence $X_n X_{n-1} \cdots X_1$, where $(X_n)_{n \geq 1}$ is a sequence of i.i.d. 2×2 stochastic matrices such that the random components C_n and D_n in the first column of X_n are independent, is identified here in a number of discrete situations. A general method is presented and it covers the cases when C_n and D_n have the same (or different) Bernoulli distributions. For example, if for a given positive integer k , kC_n and kD_n are each Bernoulli(p), $0 < p < 1$ (which means, each C_n and D_n has the distribution given by the probability measure $p\delta_{\{\frac{1}{k}\}} + (1-p)\delta_{\{0\}}$), then the corresponding limit distribution λ in the case $k = 2$ satisfies: $\lambda(A) = 1$ where $A = \left\{ \frac{s}{2^n} : s = 0 \text{ or odd and } 1 \leq s \leq 2^{n-1}, 1 \leq n < \infty \right\}$, and for each $\frac{s}{2^n} \in A$, $\lambda\left(\frac{s}{2^n}\right)$ is positive and known. Here, a singleton x in the support of λ represents the stochastic matrix whose both rows are $(x, 1-x)$. For $k > 2$, $S(\lambda)$, the support of λ is a set like the Cantor set. (Received September 21, 2012)

- 1086-60-1346 **Kevin Coltin*** (kcoltin@asu.edu). *Optimal strategy for casino blackjack: A Markov chain approach.*

By modeling the game of casino blackjack as a Markov chain, I derive the optimal strategy for the game without using simulations. I present a replicable algorithm for calculating this optimal strategy that can be easily modified to account for variations in casino rules. A player using this strategy will reduce the casino's advantage

to 0.498%, meaning that the player will lose an average of 50 cents for every \$100 bet. (Received September 21, 2012)

- 1086-60-1359 **Olusegun M Otunuga*** (otunuga@mail.usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 east Fowler Avenue, CMC 342, Tampa, FL 33620-5700, and **Gangaram S Ladde** (gladde@usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 East Folor Avenue, CMC 342, Tampa, FL 33620-5700. *Nonlinear Stochastic Energy Spot Prices Processes with Delayed Volatility*. Preliminary report.

We consider a risky asset $S(t)$ defined as $S(t) = \exp(x_2(t) + f(t))$ with riskless asset $B(t) = B_0 \exp(rt)$. The risky asset $S(t)$ consists of a non-seasonal non-linear stochastic process $x_2(t)$ which has a non-linear stochastic mean level $x_1(t)$ and a non-stationary stochastic volatility functional. We derive a continuous-time analogue of GARCH(1,1) model having two different sources of Wiener process for the non-stationary volatility functional. We showed that the expected square volatility under the risk-neutral measure is a deterministic delay differential equation and then constructed a numerical solution for the model. In addition, by developing a moving average-type model for a volatility process, an attempt is made to compare the merits and demerits of these to approaches. (Received September 21, 2012)

- 1086-60-1425 **David German*** (dgerman@cmc.edu), Claremont McKenna College, Department of Mathematics, 850 Columbia Ave, Claremont, CA 91711, and **Henry Schellhorn** (henry.schellhorn@cgu.edu), Claremont Graduate University, Institute of Mathematical Sciences, 150 E. 10th Str., Claremont, CA 91711. *A No-Arbitrage Model of Liquidity in Financial Markets involving Brownian Sheets*.

We consider a dynamic market model where buyers and sellers submit limit orders. If at a given moment in time, the buyer is unable to complete his entire order, the unmatched part of the order is recorded in the order book. Subsequently these buy unmatched orders may be matched with new incoming sell orders. The resulting demand curve constitutes the sole input to our model. The clearing price is then calculated using the market clearing condition. We use a Brownian sheet to model the demand curve, and provide some theoretical assumptions under which such a model is justified.

We prove that if there exists a unique equivalent martingale measure for the clearing price, then under some mild assumptions there is no arbitrage. We use the Ito- Wentzell lemma to obtain that result, and to characterize the dynamics of the demand curve and of the clearing price in the equivalent measure. We find that the volatility of the clearing price is (up to a stochastic factor) inversely proportional to the sum of buy and sell order flow density (evaluated at the clearing price). We also demonstrate that our approach is implementable. We use real order book data and simulate option prices under a particularly simple parameterization of our model. (Received September 21, 2012)

- 1086-60-1429 **Natasha Blitvić*** (natasha.blitvic@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *Two-parameter Non-commutative Central Limit Theorem*.

The starting point for this talk is the question: how might one discover meaningful quantum statistics? The Gaussian, semicircular and, more generally, the q -Gaussian measures play a fundamental role in classical, free, and q -deformed probability, respectively, with the latter referring to the setting of q -deformed canonical commutation/anti-commutation relations. In 1992, Speicher showed that the q -Gaussian statistics can also be realized as Central Limit Theorem-type limits of stochastic mixtures of commuting and anti-commuting elements. In this talk, we will show how to generalize Speicher's theorem to a setting where the elements are assumed to commute with respect to real-valued commutation coefficients, as opposed to commutation signs. A natural specialization will then give rise to the (q, t) -Gaussian statistics, a two-parameter family of real-valued probability measures with natural Fock-space representations and rich ties to special functions, orthogonal polynomials, and combinatorics (further discussed in abstract 1086-60-836). We will also construct general random matrix models, by introducing a suitable two-parameter deformation of the Jordan-Wigner construction, and discuss their application to the first order statistics of reduced Wigner processes. (Received September 21, 2012)

- 1086-60-1476 **Maxim J. Goldberg** (mgoldber@ramapo.edu), 505 Ramapo Valley Road, Mahwah, NJ 07430, and **Seonja Kim*** (seonja777@hotmail.com). *Using a dyadic decomposition of the time until diffusion densities overlap to define a new diffusion distance*. Preliminary report.

Diffusion distances have been successfully used in applications such as data organization and approximately isometric embedding of high dimensional data in low dimensional Euclidean space. One recent proposal for

a diffusion distance is to define separation between two points as the first *time* that the diffusion densities “spreading” from the points overlap sufficiently. In this work, we consider two “reactive” elements, each diffusing from one of two data points under the action of successive powers of a Markov matrix. When a particle of one of the elements meets a particle of the other element, we view them as bonding together (and remaining bonded from that tick of the clock onward). Eventually sufficient overlap of Dirac densities spreading from the two points corresponds to cumulatively sufficient bonding of the two elements. We define two (non-linear) operators—the Merge and the Reduce operators—to keep track of bonded and unbonded elements in time. We then use these operators to construct a dyadic decomposition of the time of bonding. This decomposition allows us to define an efficiently computable weighted average, over paths with total probability more than a specified threshold, of the time until sufficient density overlap occurs. (Received September 22, 2012)

1086-60-1506 **Arjuna Flenner*** (aflenner@gmail.com), 1900 N. Knox Road, China Lake, CA 93555, and **Gary Hewer**, 1900 N. Knox Road, China Lake, CA 93555. *Automatically Structuring Unstructured Data: A Probabilistic Approach and Open Questions.*

Data is ubiquitous in the modern world where sensors and storage devices have become cheap. This data, however, arrives mainly unstructured with very little metadata such as GPS coordinates or time stamps added. Furthermore, the amount of data precludes structuring by manual means; therefore, automated techniques to structure the data are essential, where the structured data must be useful for mission objectives. We describe some tools to better structure image data based on probability modeling, non-parametric Bayesian analysis, and probability tail bounds. In particular, we consider the problems of vanishing point detection, image labeling, and content based search. The approach presented demonstrates state of the art results in these problems, but there are open convergence and stability questions that we will discuss. (Received September 22, 2012)

1086-60-1551 **Adina Oprisan***, Barry University, Miami Shores, FL 33154. *Large deviations via almost sure CLT for functionals of Markov processes.*

We consider additive functionals of continuous time Markov processes and prove that their functional central limit theorems admit almost sure versions based on empirical measures with logarithmic averaging. For the corresponding empirical processes, we prove a large deviation principle based on a martingale decomposition, established here for additive functionals of Markov processes. (Received September 23, 2012)

1086-60-1556 **J Gani** and **Randall Swift*** (rjswift@csupomona.edu), Department of Mathematics & Statistics, California State Polytechnic University, Pomona, CA 91768. *Models for the spread of Chlamydia.*

We consider deterministic and stochastic models for the spread of Chlamydia in a closed population. Explicit solutions for an approximate model, as well in terms of Laplace transforms for the exact model are presented. (Received September 23, 2012)

1086-60-1577 **Percy H. Brill*** (brill@uwindsor.ca), Depts. of Management Sci. and Math. and Stat., University of Windsor, 401 Sunset Avenue, Windsor, Ontario N9B 3P4, Canada. *Alternative Analysis of a Renewal Problem.*

We apply a level crossing technique to analyze a renewal process where the inter-arrival times have a finite support, e.g., are uniformly distributed on $(0, 1)$ ($U(0,1)$). We derive an explicit formula for the expected number of renewals required to first exceed a barrier K greater than the upper limit of the finite support, e.g., $K > 1$ when inter-arrivals are $U(0,1)$. We also develop a corresponding asymptotic formula for the expected number of required renewals, as K tends to infinity. The method of analysis can be applied to determine the expected number of demands during an ordering cycle of an $\langle s, S \rangle$ inventory system, and related quantities in queues, and other stochastic models. (Received September 23, 2012)

1086-60-1648 **Nathaniel Eldredge*** (neldredge@math.cornell.edu) and **Laurent Saloff-Coste** (lsc@math.cornell.edu). *Widder's theorem for symmetric local Dirichlet forms.*

Classically, Widder's theorem says that any nonnegative solution $u(t, x)$ of the heat equation $(\partial_t - \frac{1}{2}\Delta)u = 0$ on $(0, T) \times \mathbb{R}^d$ is uniquely determined by its initial values at time $t = 0$; in particular, no growth conditions on u need be assumed. We present an extension of this theorem in which \mathbb{R}^d is replaced by a metric measure space equipped with a symmetric, strictly local, regular Dirichlet form $(\mathcal{E}, \mathbb{D})$ satisfying certain assumptions. Examples include Riemannian and sub-Riemannian manifolds as well as various fractals. A key ingredient is a parabolic Harnack inequality for local weak solutions of the heat equation defined by $(\mathcal{E}, \mathbb{D})$. (Received September 23, 2012)

- 1086-60-1671 **M. M. Rao** (rao@math.ucr.edu) and **Bertram M. Schreiber*** (bert@math.wayne.edu). *Representation of K -Isotropic Harmonizable Random Fields and Completely Bounded Multilinear Forms.*

Let K be a compact group acting as a transformation group via automorphisms on the locally compact group G . Then K acts in the canonical way on unitary representations of G , and thus on both $C^*(G)$ and its dual, $B(G)$. More generally, if we let K act diagonally on $G \times \cdots \times G$, then this induces an action of K on the Haagerup tensor product $C^*(G) \otimes_h \cdots \otimes_h C^*(G)$ and its dual space. A functional u in this dual space is called K -isotropic if $u^\kappa = u \ \forall \ \kappa \in K$, where u^κ denotes the image of u under the action of κ . When u is completely positive, a representation of the Fourier transform of u , as a function on $G \times \cdots \times G$, can be formulated in terms of K -spherical functions on G . When $K = SO(d)$, and K acts on $\mathbb{R}^d \times \mathbb{R}^d$, this leads to a representation theorem for isotropic, weakly harmonizable processes. (Received September 24, 2012)

- 1086-60-1708 **Tomoyuki Ichiba*** (ichiba@pstat.ucsb.edu), Dept. of Statistics and Applied Probability, South Hall 5607A University of California, Santa Barbara, CA 93106. *Two competing companies with rank based characteristics.*

We consider two competing companies whose capitals are modeled by diffusions with infinitesimal generator

$$\begin{aligned} \mathcal{L} := \mathbf{1}_{\{x_1 > x_2\}} & \left(\frac{\rho^2}{2} \frac{\partial^2}{\partial x_1^2} + \frac{\sigma^2}{2} \frac{\partial^2}{\partial x_2^2} + (\gamma_1 + g_1) \frac{\partial}{\partial x_1} + (\gamma_2 + g_2) \frac{\partial}{\partial x_2} \right) \\ & + \mathbf{1}_{\{x_1 \leq x_2\}} \left(\frac{\sigma^2}{2} \frac{\partial^2}{\partial x_1^2} + \frac{\rho^2}{2} \frac{\partial^2}{\partial x_2^2} + (\gamma_1 + g_2) \frac{\partial}{\partial x_1} + (\gamma_2 + g_1) \frac{\partial}{\partial x_2} \right), \end{aligned}$$

where the local drift and variance characteristics are assigned by rank with constraints on constants $g_1 + g_2 + \gamma_1 + \gamma_2 = 0$, $\gamma_i + g_1 < 0$, $i = 1, 2$, $\rho^2 \geq 0$, $\sigma^2 \geq 0$, $\rho^2 + \sigma^2 = 1$. This model is an extension of E. R. FERNHOLZ, T. ICHIBA, I. KARATZAS, V. PROKAJ (2011). On some probability space we construct such diffusions and analyze their properties. Questions of pathwise uniqueness, transition probabilities and some related backward stochastic differential equations are also addressed. Based on the construction and analysis of the diffusions we argue investment strategies in the model. (Received September 24, 2012)

- 1086-60-1739 **Mariana Olvera-Cravioto*** (molvera@ieor.columbia.edu), 500 W. 120th Street, Room 306, S.W. Mudd building, New York, NY 10027, **Ningyuan Chen** (nc2462@columbia.edu), 500 W. 120th Street, 3rd floor, S.W. Mudd building, New York, NY 10027, and **Nelly Litvak** (n.litvak@utwente.nl), Dep. Stochastic Operational Research, P.O. Box 217, 7500 AE Enschede, Netherlands. *Stochastic fixed-point equations arising in the analysis of algorithms.*

The probabilistic analysis of information ranking algorithms such as Google's PageRank naturally leads to an approximation in terms of the solution to a linear nonhomogeneous fixed-point equation on a weighted branching tree. Using an appropriate random graph model we show how the tree approximation is justified and therefore the analysis of linear algorithms on certain types of graphs is equivalent to the analysis of a related fixed-point equation. We also mention some of the recent results that describe the asymptotic behavior of the solutions to such equations. (Received September 24, 2012)

- 1086-60-1771 **Janusz S Golec*** (golec@fordham.edu), Department of Mathematics, Fordham University, Bronx, NY 10458. *On Logistic Models and their Properties.*

In this talk various types of logistic models will be presented. Properties, such as existence, uniqueness and stability of their solutions will be considered. Numerical methods for finding their solutions will be also discussed. (Received September 24, 2012)

- 1086-60-1782 **Paul H Bezandry***, 2441 6th Street, NW, Washington, DC 20059. *Note on the almost periodic stochastic Beverton-Holt equation.*

We consider a stochastic Beverton-Holt difference equation with varying survival rates and intrinsic growth rates. We assume that both the recruitment function and the survival rate vary randomly. In this talk we develop a basic theory of mean almost periodic random sequences on \mathbf{Z}_+ and provide a method to constructing mean almost periodic random sequences on \mathbf{Z}_+ . These techniques are, subsequently, used to find some sufficient conditions for the existence and uniqueness of a mean almost periodic solution of the Beverton-Holt equation. (Received September 24, 2012)

- 1086-60-1816 **Daniel Dobbs*** (dwd2r@virginia.edu), P. O. Box 400137, University of Virginia, Charlottesville, VA 22904. *Smoothness Properties of the Law of Brownian Motion in Certain Infinite Dimensional Spaces.*

A measure μ on \mathbb{R}^n may be called *smooth* if $d\mu = \rho d(\text{Lebesgue})$ for a smooth function ρ . While this definition of smoothness is problematic in infinite dimensions, there are definitions of smoothness that do apply to measures in infinite dimensional spaces. We will show that the law of a Brownian motion on certain infinite dimensional curved spaces has smooth properties. (Received September 25, 2012)

- 1086-60-1821 **Divine Tito Wanduku*** (wandukudivine@yahoo.com), 3170 Grand pavilion dr. Unit 101, Tampa, FL 33613, and **Gangaram S Ladde** (gladde@usf.edu), 4202 East Fowler Avenue, PHY, Tampa, FL 33620. *GLOBAL ANALYSIS OF A STOCHASTIC TWO-SCALE NETWORK HUMAN EPIDEMIC DYNAMIC MODEL WITH VARYING IMMUNITY PERIOD.* Preliminary report.

The recent rapid spread of infectious diseases of humans is closely associated with the spatial complex human population structure and the underlying large-scale inter-patch connection human transportation. Furthermore, the fluctuations in disease endemicity within patch dwelling populations are closely related with the hereditary features of the disease. We present a stochastic SIR delayed dynamic epidemic model for a two-scale dynamic structured population. The disease confers varying time infection acquired immunity to recovered individuals. The varying time delay period accounts for the time-lag during which recovered individuals with conferred infection acquired immunity become susceptible. We investigate the stochastic asymptotic stability of the disease free equilibrium of the two-scale structured mobile dynamic population, and further examine the impacts on the eradication of the disease. (Received September 24, 2012)

- 1086-60-1837 **Armando Arciniega*** (armando.arciniega@utsa.edu), **Michael Broome** and **Gabby Prieto.** *Stochastic Modeling of Parasites in Host Populations.*

The complexity of the host-parasite relationship, and its depression of host populations has been investigated and successfully modeled for large populations using deterministic methods. These models fail to accurately predict interactions within smaller populations, and require a statistical component to reclaim some degree of accuracy. This research employs stochastic differential equations to better forecast changes in small populations. (Received September 24, 2012)

- 1086-60-1839 **Kevin Schwenkler*** (kas09@hampshire.edu), **Angelica Deibel** (angelica.deibel@gmail.com), **Laura Veith** and **Yevgeniy Kovchegov.** *Inhomogeneous Quantum Walks.* Preliminary report.

We examined three different types of one-dimensional quantumwalks, all exhibit some degree of inhomogeneity. The first is inhomogeneous only insofar as the coin operator differs at even and odd positions along the line. The second has a coin operator that is inhomogeneous and oscillatory in time. The third has a coin operator that is inhomogeneous and oscillatory in space, differing at every position along the line. Much progress is made towards attaining asymptotics for the first walk, although our analytical solution does not yet agree with the numerics. An asymptotic approach is attempted for the second walk, although it seems that this approach may not be well-suited to the walk. The third walk, it seems, requires more machinery, although progress is made using symmetry and a pentadiagonal transition operator is obtained. This general pentadiagonal operator gives hope for much progress in the near future. (Received September 24, 2012)

- 1086-60-1860 **Mike O'Neill*** (moneill@cmc.edu). *Winding, twisting and separation properties of exiting Brownian motion.* Preliminary report.

We will discuss the almost sure winding, separation and twisting properties of Brownian motion upon exiting a domain $\Omega \subset \mathbb{R}^n$ ($n = 2$ or $n = 3$), under various conditions on the geometry, dimension or capacity of Ω or $\partial\Omega$. (Received September 24, 2012)

- 1086-60-1920 **Ashley L Webber*** (ashleywebber7@gmail.com). *The Mathematical Modeling of Multifocal Tumors.*

This talk will discuss some stochastic modeling approaches for the growth of high-grade malignant brain tumors (glioblastoma multiforme) on realistic geometries. I will describe and justify the addition of an Ornstein-Uhlenbeck process to model the local growth rates of the tumor and will show qualitatively good agreement with actual patient cases of multifocal tumors. (Received September 24, 2012)

- 1086-60-2064 **Tiffany Nicole Kolba*** (tiffany.kolba@valpo.edu). *A Systematic Lyapunov Construction for Proving Noise-Induced Stabilization.*

Noise-induced stabilization occurs when an unstable deterministic system is stabilized by the addition of white noise. Proving that this phenomenon occurs for a particular system is often manifested through the construction of a global Lyapunov function. However, the procedure for constructing a Lyapunov function is often quite ad hoc, involving much time and tedium. In this talk, a systematic algorithm for the construction of a global Lyapunov function for planar systems will be presented. The general methodology is to construct a sequence of local Lyapunov functions in different regions of the plane, where the regions are delineated by different behaviors of the deterministic dynamics, and then patch the local Lyapunov functions together to form one smooth global Lyapunov function. The algorithm is applied to a model problem which displays finite time blow up in the deterministic setting in order to prove that the system exhibits noise-induced stabilization. (Received September 24, 2012)

- 1086-60-2081 **Etsuo Segawa*** (e-segawa@m.tohoku.a.c.jp). *On the study of quantum graph : a mapping to coined quantum walk.* Preliminary report.

Quantum graph of a graph G is a system of Schrödinger equations on edges which have Euclidean length with boundary conditions at each joint part, i.e., vertex of the graph. On the other hand, the coined quantum walk of graph G also describes a discrete-time dynamics on G which is considered as a quantum analogue of a discrete-time random walk. We find a connection between two systems, more concretely, a stationary state of the coined quantum walk in a special class describes the eigenfunction of the quantum graph. (Received September 24, 2012)

- 1086-60-2105 **Liqing Yan*** (liqingyan2020@gmail.com), Department of Mathematics, Institute of Natural Science, 800 Dongchuan Road, Minhang District, Shanghai 200240. *Fast and Exact Simulation for the CIR processes.* Preliminary report.

We present an easy, fast and exact simulation method for the CIR processes. Our method is much faster than the Poisson method, which samples from gamma distributions with the shape parameter being a Poisson distribution. Our exact simulation is also faster than the numerical schemes when they require more discrete time points to reduce their discretization errors. The Poisson method is exact but unacceptably slow. The discretization schemes are fast, but involve big discretization errors. Due to the non-Lipschitzian diffusion coefficient function near zero, the discretization errors caused by numerical methods converge to zero very slowly, especially when the process is close to zero. Our method is exact and has no such troubles caused by the square-root function. (Received September 24, 2012)

- 1086-60-2144 **Aaron M Montgomery*** (amontgom@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *Collisions of Independent Random Walks on Graphs.*

We consider the problem of two simple, independent random walks on an infinite graph and ask with what probability the two walks will collide into each other infinitely often. We will discuss strategies for answering this question in the case of a recurrent graph, and will motivate the complexity of the question for transient graphs with a sequence of examples. (Received September 24, 2012)

- 1086-60-2200 **Michael Ludkovski*** (ludkovski@pstat.ucsb.edu). *Interacting Particle Systems for Systemic Risk.* Preliminary report.

We propose an interacting particle system description of the banking system. While net bank assets evolve independently under normal conditions, defaults trigger a mean-field type interaction that creates systemic risk. We work with a stochastic size of the economy, with new banks added spontaneously according to a mean-field birth process. We discuss stability of the system and numerical analysis of the likely paths of systemic failure and corresponding rare event probabilities. (Joint work with Tomoyuki Ichiba (UCSB).) (Received September 25, 2012)

- 1086-60-2265 **Kumer Pial Das***, 1 Bluff Trail, Chapel Hill, NC 27516. *Stochastic Models in Organ Transplantation.* Preliminary report.

Consider a discrete time Markov Decision Process (MDP) studying the problem of optimal timing of an organ transplantation assuming the patient has found a compatible live donor. This study investigates the optimal reward for various forms of transition probability matrix (P). In particular, results have been discussed when P is an upper triangular matrix or when P is stochastically increasing. (Received September 25, 2012)

1086-60-2697 **Timothy Chumley*** (tim@math.wustl.edu). *Diffusivity in multiple scattering systems.*

We study a class of random dynamical systems derived from particle-surface systems involving classical scattering and certain random walks derived from them. Of particular interest is the connection between surface microstructure and diffusion characteristics of the derived random walks. The main results, a central limit theorem and weak invariance principle, express the diffusivity of a limit diffusion process in terms of the spectrum of a Markov scattering operator. (Received September 25, 2012)

1086-60-2741 **Miklos Abert, Endre Csoka, Gabor Lippner*** (lippner@math.harvard.edu) and **Tamas Terpai.** *Invariant perfect matchings in Cayley graphs via short augmenting paths in expanders.* Preliminary report.

We show that given a partial matching in a large finite d -regular expander graph, there is always a short augmenting path. Our main application is the construction of factor of IID perfect matchings in expander Cayley graphs. This answers a question asked by Lyons and Nazarov, who settled the bipartite case in 2011.

We also prove that every infinite, connected vertex transitive graph has a perfect matching. This in turn implies every Cayley graph has a translation invariant probability measure on the set of its perfect matchings. (Received September 25, 2012)

1086-60-2882 **Ibukun O Amusan*** (iamusan@math.fsu.edu). *Option pricing under a coupled additive-multiplicative stochastic volatility model.* Preliminary report.

We look at the pricing of options under an additive and multiplicative noise model for stochastic volatility. Empirical results obtained in a previous study indicated that the associated stochastic process might be appropriate for modeling volatility of stock returns. We present some option prices and compare them to those obtained from other popular models. (Received September 25, 2012)

1086-60-2883 **William A Massey*** (wmassey@princeton.edu), ORFE Department, Sherrerd Hall, Princeton University, Princeton, NJ 08544. *Stochastic Iteration for Probability Measures on Posets.* Preliminary report.

The space of probability measures on a partially ordered set (poset) inherits a family of partial ordering relations that are called stochastic orderings. We define a stochastic iteration to be the repeated application of some self mapping on this space of probability measures that is isotone (increasing or decreasing) with respect to a given stochastic ordering. The theory of fixed points for isotone mappings on posets then give us a variety of iteration methods for constructing random distributions. In turn, these results yield new types of simulation algorithms for queueing theory. (Received September 25, 2012)

1086-60-2945 **Kursad Tosun*** (ktosun@siu.edu), Department of Mathematics, Southern Illinois University, 1245 Lincoln Drive Mail Code 4408, Carbondale, IL 62901. *Qualitative Analysis of Stochastic SIR Model with Disease Deaths.*

SIR models are compartmental models in mathematical epidemiology which divide the population into three classes, Susceptible-Infected-Removed. We discuss existence, uniqueness, and invariance property of solutions and stochastic asymptotic stability of disease free and endemic equilibria. (Received September 26, 2012)

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1086-62-123 **S. E. Tolwinski-Ward*** (tolwinski@math.arizona.edu), **M. P. Tingley, M. N. Evans** and **D. W. Nychka.** *Forward and inverse modeling of the nonlinear relationship between tree-ring width and climate.*

Natural proxy records are generally the result of lossy, nonlinear interactions between multivariate climate and the biological or physical recording process of the specific proxy archive. The width of tree rings depends on variations in temperature and moisture resources integrated over time. Yet regression-based climate reconstructions typically treat tree-ring width as information-preserving and linearly related to a single climate variable.

We present a simple yet biologically-motivated nonlinear forward model for tree-ring width as a function of monthly temperature and precipitation inputs. The validated model, called VS-Lite, is used to describe the climate-proxy relationship within a Bayesian hierarchical modeling solution to the inverse problem of reconstructing climate from ring width data. Like the real-world ring-width recording process, VS-Lite is not a one-to-one mapping between the space of climate histories and the space of modeled ring width series. The resulting nonidentifiability in our inverse statistical model is partly overcome when the model is combined with prior climatic information encoded in the Bayesian model. The rest is translated into a rigorous and realistic representation of uncertainty in the resulting estimates of climate. (Received July 25, 2012)

- 1086-62-129 **Kristin C. Mara*** (kmara08@winona.edu), 960 South Beaumont Road, Prairie du Chien, WI 53821, and **Samantha Louise Meadows** and **Rosemarie Roessel**. *Semiparametric Regression for Measurement of Parts Data*.

We will approximate the smooth function by a truncated polynomial basis with degree 2, which contains the polynomial basis and the splines constructed by knots. After we fix the number of knots, the function is estimated by methods such as OLS, penalized spline regression and linear mixed model. We propose our version of Bayesian penalized spline, which provides comparable results. The prior distribution is chosen to be “objective” so it will minimize the influence to the posterior distribution and maintain the advantages Bayesian statistics provided. The Jeffreys prior is adopted for the polynomial basis and the variance component in the model. The prior for the splines constructed by knots is elicited from the penalty term in the penalized likelihood. To ensure the posterior distributions are proper, we have to use an informative prior on the smoothing parameter. To achieve the goal of having an “objective” prior for the smoothing parameter, we will use the df_{fit} to determine the hyperparameter in the prior distribution. After we fit a nonparametric model, we will look at a semiparametric model, which will combine our nonparametric model with a categorical variable. We will use the AIC to compare those methods proposed through a simulated and a manufacturing data set. (Received July 26, 2012)

- 1086-62-172 **Adam J Zarn*** (adam.zarn@my.wheaton.edu), **Elliott Z Hollifield** (ehollifi@unca.edu) and **Victoria A Trevino** (trevino.victoria@yahoo.com). *A Survival Analysis of the Duration of Olympic Records*.

We use recurrent-events survival analysis techniques and methods to analyze the duration of Olympic records. The Kaplan-Meier estimator is used to perform preliminary tests and recurrent event survivor function estimators proposed by Wang & Chang (1999) and Pena et al. (2001) are used to estimate survival curves. Extensions of the Cox Proportional Hazards model are employed as well as a discrete-time logistic model for repeated events to estimate models and quantify parameter significance. The logistic model was the best fit to the data according to the Akaike Information Criterion (AIC). We discuss, in detail, covariate significance for this model and also predict that roughly 20 to 30 records, of the 51 relevant events considered, will be broken in the 2012 Olympic Games in London. (Received August 02, 2012)

- 1086-62-202 **Lin Han** (linhan@ic.sunysb.edu) and **James R. Stinecipher*** (jstinecipher@mail.fresnostate.edu). *Survival Analysis on Patients with Chronic Hepatitis B*.

Chronic hepatitis B is a major health problem that affects over 350 million people worldwide. In this research, we model the onset of liver cancer in Taiwanese patients with hepatitis B using the REVEAL-HBV dataset. We construct proportional hazards models considering both time-independent and time-dependent covariates and use stepwise selection to exclude insignificant risk factors. We assess the models using residual analyses and likelihood score comparisons, namely the Akaike Information Criterion (AIC). We demonstrate that a proportional hazards model which considers liver cirrhosis as a time-dependent covariate is more efficient than other time-independent models. We also show that the development of liver cirrhosis has the highest hazard ratio among other covariates in the model. We conclude that early diagnosis and treatment of liver cirrhosis in hepatitis B patients can have a major effect in preventing the onset of liver cancer. (Received August 06, 2012)

- 1086-62-246 **T. Vance*** (tia_l_vance@hotmail.com), Princess Anne, MD, **D. Pokrajac**, Dover, DE, **A. Lazarevic**, Hartford, CT, **N. Reljin**, Dover, DE, **N. Melikechi**, Dover, DE, **A. Marciano**, Dover, DE, and **Y. Markushin**, Dover, DE. *Data Mining for Complex Biochemistry Spectroscopy Data*.

In recent years, the spectroscopy community has increasingly been using various techniques for automatic computer assisted quantitative and qualitative evaluation of specimen based on spectroscopy data. Laser induced breakdown spectroscopy (LIBS) surges as a fast, versatile and powerful analytical technique with the ability to make remote measurements in field environments. We perform multi-class classification of LIBS data of four proteins: BSA (most abundant protein in blood plasma), Osteopontin, Leptin and IGF II (potential biomarkers for ovarian cancer). Principal Component Analysis (PCA) is applied on the data for feature extraction. Classification is performed using K-nearest neighbor, classification and regression trees, neural networks, support vector machines, and adaptive local hyperplane. Discrimination of potential cancer biomarkers vs. a common blood plasma protein can lead to the identification of elemental fingerprints of biological and chemical components that are vital in the early detection of cancer based on spectroscopy data. Our approach demonstrates that highly accurate automatic classification of complex protein samples is possible on LIBS data, using PCA with sufficiently large number of extracted features and appropriate classification techniques. (Received September 22, 2012)

- 1086-62-349 **Salilesh Mukhopadhyay*** (smukhopadhyay@optonline.net), 8 Green Hill Road, Hackettstown, NJ 07840-5687. *Asymptotic Bayesian Analysis of The Capital Asset Pricing Model.*

One of the salient problems of modern financial economics is the quantification of the tradeoff between risk and expected return. The Capital Asset Pricing Model [CAPM] enables the economists to quantify risk and the reward for bearing it. Asymptotic Bayesian analysis is used to establish that the CAPM implies the expected return of an asset must be linearly related to the covariance of its return with the return of the market portfolio. Finally, the empirical Bayes approach is highlighted for large-sample statistical inference from CAPM and the new methodology for estimation and testing is presented. (Received August 23, 2012)

- 1086-62-446 **Wayne Tarrant*** (w.tarrant@wingate.edu), Department of Mathematics, Wingate University, Wingate, NC 28174. *The flat tax in post-communist Europe.* Preliminary report.

Since 1994 sixteen post-communist European nations have adopted some type of the flat tax. In some of these countries the personal and corporate tax rates are identical, while others have differentiation among the rates. Among other issues, we consider GDP growth, tax revenues, Gini coefficients, and sizes of underground economies before and after the adoption of the flat tax. There are major econometric issues to consider when estimating the size of the underground economy, and significant data quality concerns for these formerly Eastern bloc countries. We make comparisons across the different flavors of the flat tax. This is a preliminary report with a series of papers forthcoming. (Received September 10, 2012)

- 1086-62-550 **Huybrechts Bindele*** (hbindele@southalabama.edu), 411 University Blvd. North, ILB 325, Mobile, AL 36688-0002, and **Asheber Abebe.** *semi-parametric rank regression with missing response.*

In this paper, we consider a semi-parametric regression model with responses missing at random. We study the rank estimator of the regression coefficient. We establish conditions needed for the consistency and asymptotic normality of the proposed estimator. Real life examples and Monte Carlo simulation experiments show that the proposed estimator has a smaller MSE compared to that obtained based on the least squares procedure for heavy tailed or contaminated data. (Received September 06, 2012)

- 1086-62-789 **Juan M Restrepo*** (restrepo@math.arizona.edu), Mathematics Building, 617 N Sta Rita, University of Arizona, Tucson, AZ 85721, and **Darin Comeau** and **Hermann Flaschka.** *How Do You Determine Whether The Earth Is Warming Up?* Preliminary report.

How does one determine whether the high summer temperatures in Moscow of a few years ago was an extreme climatic fluctuation or the result of a systematic global warming trend? How does one perform an analysis of the causes of this summer's high temperatures in the US, if climate variability is poorly constrained? It is only under exceptional circumstances that one can determine whether a climate signal belongs to a particular statistical distribution. In fact, climate signals are rarely "statistical;" there is usually no way to obtain enough field data to produce a trend or tendency, based upon data alone. There are other challenges to obtaining a trend: inherent multi-scale manifestations, and nonlinearities and our incomplete knowledge of climate variability. We propose a trend or tendency methodology that does not make use of a parametric or a statistical assumption and it is capable of dealing with multi-scale time series. The most important feature of this trend strategy is that it is defined in very precise mathematical terms. (Received September 12, 2012)

- 1086-62-949 **Sarah Rachell Salter*** (sarah.salter226@gmail.com), 1143 Overlook Drive, Toms River, NJ 08753, and **Amanda Luby** and **Kevin Torres.** *Salmonella Outbreaks: Assessing Causes and Trends.*

According to the Center for Disease Control and Prevention, it is estimated that each year foodborne disease is the cause of roughly 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths among American citizens. Of the 31 known pathogens that contribute to domestically acquired foodborne illness, Salmonella is deemed the leading pathogen causing hospitalization and death. Although there has been greater implementation of government regulations, the CDC has confirmed that since 1998 the rate of infection of Salmonella is slightly increasing rather than decreasing. For this reason, Salmonella presents itself as a public health concern. This research focuses heavily on using Bayesian statistical methodology to determine change points using a Markov Chain Monte Carlo computational method, as well as a Bayesian Poisson Analysis. A simulation study was developed to evaluate how well these methods were able to successfully detect outbreaks and how different factors affect these results. (Received September 17, 2012)

- 1086-62-1423 **Nancy Tafolla*** (tafolla@rohan.sdsu.edu). *Error Estimation of Global Historical Data Reconstruction.*

This presentation will discuss monthly reconstruction of precipitation over the entire globe at a 2.5 by 2.5 degree resolution from January 1900 to December 2010. This historical data reconstruction uses a method of multivariate linear regression, land station observations of precipitation and empirical orthogonal functions (EOFs) to make the spatial prediction of precipitation over the entire globe. The EOFs are computed using data from the Global Historical Climatology Center (GPCC) with a 2.5 degree resolution. The station data used is from the Global Historical Climatology Network (GHCN). This presentation will specifically detail (1) the mathematical theory of reconstruction and its error estimate (2) global climate changes inferred from the reconstructed data, and (3) the 1930s mega drought of the United States and its relation to the patterns of global precipitation and sea surface temperature. (Received September 21, 2012)

- 1086-62-1752 **Mehdi Razzaghi*** (mrazzagh@bloomu.edu), Department of Mathematics, Bloomsburg University, Bloomsburg, PA 17815. *Approximating the Distribution of Fisher's Combined p-Values from Multiple Experiments with Application.* Preliminary report.

In biological experiments, genetics, epidemiology and many other fields, it is often necessary to test several hypotheses. In these experiments, the p-values from all the tests need to be combined to derive an observed significance level for the entire experiment. Fisher was the first person to consider this question as early as 1925. Fisher showed that since the p-value from each test is a uniform random variable over the interval (0,1), if the p-values from all the tests are assumed to be independent, then the distribution of the sum of the logarithms of the square of the reciprocals of the p-values is a Chi square distribution. This property may work well in certain situations. However, in many experiments, the assumption of independence of p-values can lead to erroneous and invalid results. There have been several attempts to generalize the Fisher's results to situations when p-values are dependent. To date, there is no universally accepted method for combining dependent p-values. Here, we derive an approximation to the moment generation function of the Fisher's statistic when p-values are dependent. The moments of the joint distribution of the product of p-values is expressed as a linear model whose parameters are estimated by using a sequence of fractional moments. (Received September 24, 2012)

- 1086-62-2078 **Zhiyi Chi and Sairam Rayaprolu*** (sairam.rayaprolu@uconn.edu). *Denoising a long locally dependent binary signal sequence: multiple-testing with approximate posterior-likelihood.*

Large scale multiple hypothesis testing plays an important role in biomedical imaging and genomic data processing. Stochastic dependence among the signals is known to adversely affect both the false discovery proportion and the detection power of large-scale multiple tests. Among the causes of the drop in performance are the usage of procedures proven to work only for independent signals and the unknown underlying dependence structure amongst the signals. This talk addresses the issue for the case of a stationary, ergodic signal vector with low signal-strength and known noise distribution. In this setting, a new approach for improved recovery of a long sequence of dependent binary signals embedded in noisy observations is presented. A Bayesian multiple-testing procedure with desirable optimality properties but without the assumption of independence is used. The input to the procedure is a sequence of posterior probabilities obtained using second-order Taylor series approximations and estimated second-order moments of observations. Numerical results are presented for the cases of additive and multiplicative noise. Although we only consider signal vectors registered as a time series, the approach in principle may apply to random fields as well. (Received September 24, 2012)

- 1086-62-2417 **Xin Zhang, Jun Li, Vance Wong, Brian Noland and Daniel Jeske*** (daniel.jeske@ucr.edu), Department of Statistics, 1340 Olmsted Hall, Riverside, CA 92521. *Logistic Regression Classifiers with Longitudinal Data.*

We propose a robust two-group classification methodology for longitudinal data applications. The classifier is built as follows. A nonparametric mixed effects (NME) model is fit to training data. Nonparametric basis functions are used to capture the underlying group-dependent time trends and subject-specific random intercepts and slopes are used to tune the model for subject heterogeneity. The NME is used to obtain empirical best linear unbiased predictions (eBLUPs) for the slopes and intercept of each subject. A logistic regression model whose explanatory variables are eBLUPs is fit and used to evaluate the posterior membership probability for, say Group 1. A classification threshold for the posterior membership probability is determined from a receiving operating curve (ROC) analysis. New subjects are classified by evaluating their eBLUPs, inserting them into the logistic regression model, and comparing the posterior membership probability for Group 1 to the selected threshold. We illustrate the use of this methodology and then compare and contrast its effectiveness to an alternative

approach where the measured responses at each time point are used directly in a logistic regression classifier. (Received September 25, 2012)

- 1086-62-2517 **Tanujit Dey** (tdey@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187, and **Daniel Vasiliu*** (dvasiliu@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187. *Irrelevance based criterion for variable selection.*

In synchrony with the current advancement of science and technology, more complex and multi-dimensional data becomes ubiquitous. This status quo is both challenge and incentive for considering variable selection problems in generally ill-defined situations (number of variables in the data exceeding and having no predetermined relationship to the number of observations). In this research, by assuming the framework of a linear model, our principle goal is to identify the relationship between certain outcomes and a few variables from the data set. Considering high to ultra-high dimensional cases, most variables are believed not responsible for expressing the outcome. Hence the objective would be to abandon those irrelevant variables from the data and hold on to only those that are more relevant for expressing the outcome. In order to do so we propose a novel variable selection procedure along with supportive theoretical results. Extensive simulation studies have been performed to illustrate the performance of the proposed methodology in comparison with other familiar methods from the specialty literature. A number of real data sets have been analyzed from the point of view of the predictive performance to defend the novelty of the proposed approach. (Received September 25, 2012)

- 1086-62-2577 **K. M. Kinnaid*** (katherine.m.kinnaid.gr@dartmouth.edu), 27 N. Main Street, 6188 Kemeny Hall, Hanover, NH 03755. *Multiscale Representations of High-Dimensional Data in Music Comparison Tasks.* Preliminary report.

We propose a novel multiscale representation of high-dimensional and noisy data that encodes relevant and size-appropriate information, while also being of a manageable dimension. We apply this representation to Music Information Retrieval (MIR) classification tasks by building a signature of each song in our data set that captures repetitive structure at several scales. Given a specific MIR comparison task, such as finding cover songs or remixes of a given song, we apply the appropriate metric to this representation space allowing for a fine-tuned comparison between songs. This multiscale approach differs from those in the literature that largely consider single-scale, single-feature representations. (Received September 25, 2012)

- 1086-62-2631 **Keshav P Pokhrel*** (kpokhrel@mail.usf.edu), FL, and **Chris P Tsokos** (ctsokos@usf.edu), FL. *Forecasting Using Functional Data Analysis Models in Cancer Epidemiology.*

An increasing incidence of brain cancer has been reported for the last three decades. In this study of brain cancer incidence and mortality in the US, we attempt to explore the information on rate function in longitudinal studies by examining data provided by the Surveillance, Epidemiology, and End Results (SEER) Program. Population-based data from the SEER Program are used to calculate the incidence, mortality and survival rates for people with brain cancer. We use annual unadjusted brain cancer mortality rates from 1969 to 2009 in 5-year age groups for the different regions of United States. Age-specific mortality curves were obtained using nonparametric smoothing methods. The importance of regional differences is studied to identify the cause of the subject. We apply functional time series models on age-specific brain cancer mortality rates for each group of patients, and forecast their mortality curves using exponential smoothing state-space models with damping. (Received September 25, 2012)

- 1086-62-2712 **Brandi A. Bailes*** (babailles@csupomona.edu) and **Jennifer M. Switkes.** *Optimization in Baseball Lineups.*

In major league baseball there is great emphasis put on star performers - finding them, rating them, paying them millions of dollars, and filling the starting lineup with them - with almost no attention given to optimization, statistically or economically. Here, we use the plethora of available baseball statistics to help resolve baseball's optimization conundrum. By using the statistic "Runs Created," based off a combination of several non-fielding baseball statistics, we attempt to find the weakest players who still create a strong enough lineup to meet a desired minimum expected winning percentage against an opposing team. Our work is heavily based on the paper "Quasigeometric Distributions and Extra Inning Baseball Games" by Darren Glass and Philip Lowry. Our contribution is in applying their ideas to optimize starting lineups, and in creating a MATLAB-based routine and user interface that sabermetric-minded managers could use in putting together their starting lineups. (Received September 25, 2012)

1086-62-2745 **Constantine Georgakis*** (cgeorgak@depaul.edu), Constantine Georgakis, Department of Mathematics, DePaul University, Chicago, IL 60712. *A Note on the Additive Seasonal Decomposition of Time Series*. Preliminary report.

Over the last 75 years a statistical methodology has evolved, which is used in the U.S. by Bureau of the Census, the Bureau of Labor Statistics, and the Federal Reserve Bank for the seasonal adjustment of leading economic indicators. The simplest model for adjusting a time series $x(t)$ for seasonal variation is the additive decomposition model. That is, $x(t) = m(t) + s(i) + e(t)$; $m(t)$ is the trend-cycle component that captures the long term movement of the series; $s(i)$ are the seasonal effects for monthly data if $i=1$ to 12 or for quarterly data if $i=1$ to 4 that are due to weather or institutional factors and sum to zero; $e(t)$ is a white noise of independent random variables with mean zero and constant variance. In this model, the trend-cycle component is estimated by applying the twelve month centered moving average to the original data series, and the seasonal effects by averaging the resulting difference between the original series and the trend-cycle estimate. We present a streamlined proof that if the trend-cycle is pure quadratic function of time then the estimators of the seasonal effects are unbiased, a result due to James Durbin. (Received September 25, 2012)

65 ► Numerical analysis

1086-65-101 **Jintao Cui*** (jxcui1@ualr.edu), Department of Mathematics and Statistics, University of Arkansas at Little Rock, Little Rock, AR 72204, and **Wujun Zhang** (wujun@umd.edu), Department of Mathematics, University of Maryland at College Park, College Park, MD 20742. *An Analysis of HDG Methods for the Helmholtz Equation*.

In this talk we discuss the hybridizable discontinuous Galerkin (HDG) methods for the Helmholtz equation with first order absorbing boundary condition in two and three dimensions. We prove that the proposed HDG methods are stable (hence well-posed) without any mesh constraint. The stability constant is independent of the polynomial degree. By using a projection-based error analysis, we also derive the error estimates in L_2 norm for piecewise polynomial spaces with arbitrary degree. This is joint work with Wujun Zhang from University of Maryland. (Received July 17, 2012)

1086-65-152 **Paul R Bouthellier*** (pbouthel@pitt.edu), 504 East Main Street, Titusville, PA 16354. *Computing 3D Rotations for Computer Graphics*.

In this talk we shall consider computational strategies for rotating 3D models in computer software. We shall use schemes involving Euler angles, quaternions, and hybrid methods. The main problem we shall examine is how to represent a given orientation with a fixed set of Euler angles that can be used by the software for rotational purposes. The problem of interpolating between two orientations is also studied. Gimbal lock and quaternion based methods will also be discussed. Examples of rotations, interpolations, Gimbal lock and wrap-around infinities will be illustrated using 3D animations created in graphics packages such as Studio 3D Max and Poser. (Received July 30, 2012)

1086-65-175 **Gerard M. Awanou***, University of Illinois Chicago, Chicago, IL 60607-7045, and **Douglas N. Arnold**. *FINITE ELEMENT DIFFERENTIAL FORMS ON CUBICAL MESHES*.

We develop a family of finite element spaces of differential forms defined on cubical meshes in any number of dimensions. The family contains elements of all polynomial degrees and all form degrees. In two dimensions, these include the serendipity finite elements and the rectangular BDM elements. In three dimensions they include a recent generalization of the serendipity spaces, and new $H(\text{curl})$ and $H(\text{div})$ finite element spaces. Spaces in the family can be combined to give finite element subcomplexes of the de Rham complex which satisfy the basic hypotheses of the finite element exterior calculus, and hence can be used for stable discretization of a variety of problems. The construction and properties of the spaces are established in a uniform manner using finite element exterior calculus. We will discuss the characterization of spaces of differential forms which are invariant under translation and scaling. (Received August 03, 2012)

1086-65-197 **Yves Nievergelt*** (ynievergelt@ewu.edu), ynievergelt@ewu.edu, and **Theodore M. Cole** and **Caroline Rinaldi**. *Fitting helices to data*.

The problem of fitting a helix to data occurs, for example, in nuclear physics, to fit a trajectory to measured positions of a charged particle moving in an electromagnetic field, and in zoology, to study the growth of rodent incisors. Relative to the sum of the distances from the data to the helix, there are data without any best-fitting helix, and data with multiple best-fitting helices. However, users do not want such a best-fitting helix either. The

regularization proposed here might be called the postman problem: minimizing twice the sum of the distances from the data to the helix plus twice the length of the fitted helical arc. Thus the objective function to be minimized is similar to the distance traveled by a postman delivering mail to houses along a dead-end street, walking along the street, marching to and from each door, and walking back along the same street but without visiting the houses again. A helix that minimizes this objective function is a helix that users want. (Received August 29, 2012)

1086-65-383 **Abner J Salgado*** (abnersg@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *A Finite Element Method for the Total Variation Flow without Regularization*. Preliminary report.

The TV flow, that is the subgradient flow of the energy generated by the BV-norm, and related equations are called very singular diffusion equations, since in flat regions ($|\nabla u| = 0$) the diffusion is so strong that becomes a nonlocal effect. We propose a method for the solution of this class of equations, which involves no regularization and is unconditionally stable and convergent. To deal with the fact that the underlying nonlinear problems are solved only approximately, we devise an a posteriori error estimator. Applications to materials science are currently under investigation. (Received August 27, 2012)

1086-65-390 **Jie Shen***, Department of Mathematics, Purdue University, West Lafayette, IN 47906. *New phase-field models and energy stable numerical schemes for multiphase flows with different densities*.

I shall present two new phase field models, one incompressible and the other quasi-incompressible, for multiphase flows with different densities. I shall also present efficient and energy stable numerical schemes, as well as some numerical results which validate the flexibility and robustness of these phase-field models. (Received August 28, 2012)

1086-65-399 **Nan Jiang*** (njiang@usd.edu), 414 E. Clark St., Vermillion, SD 57069. *On the Convergence of α Schemes*. Preliminary report.

An orderly procedure of constructing families of α and β schemes, to approximate homogeneous conservation laws, was introduced by S. Osher and S. Chakravarthy (1985,1986). Among these schemes, we are interested in the entropy consistence of the semi-discrete α schemes in the context of approximating scalar conservation laws. In general α schemes, for $0 < \alpha \leq \frac{1}{2}$ and $m = 2, 3, \dots, 8$, are $2m - 2$ order accurate methods. However when $\alpha = \frac{2}{m} \binom{2m}{m}^{-1}$, we obtain one order higher, i.e. $2m - 1$ order, accurate schemes. Although, for the homogeneous conservation laws, Osher and Chakravarthy were able to show the total variation diminishing (TVD) property of these schemes, the entropy convergence of the schemes has been open. In this paper, for all admissible values of α and $m = 2$, we extend α schemes to approximate the non-homogeneous convex conservation laws, which in general are total variation bounded (TVB). Finally, using one of our convergence criteria (2003), we have established the entropy convergence for both the original and extended α schemes. (Received September 13, 2012)

1086-65-422 **Arundhati Bagchi Misra*** (abmisra@svsu.edu) and **Hyeona Lim** (hlim@math.msstate.edu). *Nonlocal speckle denoising models based on total variation minimization*. Preliminary report.

Image denoising models are available from various mathematical fields. The initial models are derived using nonlinear partial differential equations(PDEs). Filtering models based on smoothing operators have also been used for denoising. The most successful of them was the nonlocal means method proposed by Buades, Coll and Morel in 2005. Though it is very accurate in removing noise, it is very slow and hence quite impractical. In 2008, Gilboa and Osher extended some known PDE and variational techniques in image processing to the nonlocal framework. Using nonlocal PDE operators, they proposed the nonlocal total variation method for Gaussian noise. We use this idea to develop two nonlocal PDE models for speckle noise. First we extend the speckle denoising model introduced by Krissian et al. in 2005 to the nonlocal framework. Next we develop a nonlocal PDE based accelerated diffusion speckle denoising model. For faster convergence, we use Split Bregman scheme to solve both. The new models are more accurate than the Krissian model and faster than the nonlocal means method. (Received August 31, 2012)

1086-65-465 **Abner J Salgado*** (abnersg@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *A PDE approach to fractional diffusion: a priori and a posteriori error analysis*. Preliminary report.

We study solution techniques for problems involving fractional powers of the Dirichlet Laplace operator in a bounded domain. This operator can be realized as the Dirichlet to Neumann operator of a degenerate/singular

elliptic problem posed on a semi-infinite cylinder, which we analyze in the framework of weighted Sobolev spaces. Motivated by the rapid decay of the solution of this problem, we propose a truncation that is suitable for numerical approximation. We discretize this truncation using first degree tensor product finite elements. We provide a priori error estimates for shape regular and optimal error estimates using anisotropic elements in weighted Sobolev spaces. A posteriori error estimation techniques are discussed and analyzed. To illustrate the method's performance we present numerical experiments. (Received September 03, 2012)

1086-65-502 **lei wang*** (lwang@mcs.anl.gov), 9700 S. Cass Ave., Argonne, IL 60439, and **jie chen** (jiechen@mcs.anl.gov), 9700 S. Cass Ave., Argonne, IL 60439. *Fast Evaluating Matern Covariance Kernel by a Cartesian Treecode.*

Evaluating sums of multivariate Matern kernels is a common computational task in statistical and machine learning community. The quadratic computational complexity of the summation is a significant barrier to practical applications. We develop a Cartesian treecode algorithm to efficiently estimate sums of the Matern Kernel. The method uses a far-field Taylor expansion in Cartesian coordinates to compute particle-cluster interactions. The Taylor coefficients are obtained by recurrence relations which allows efficient computation of high order approximations. In the serial code, for a given order of accuracy, the treecode CPU time scales as $O(N \log N)$ and the memory usage scales as $O(N)$, where N is the number of particles. Parallel code also gives promising scale. (Received September 05, 2012)

1086-65-564 **Alan Demlow*** (alan.demlow@uky.edu), Dept. of Mathematics, University of Kentucky, 775 Patterson Office Tower, Lexington, KY 405060027, and **Anil Hirani** (hirani@cs.illinois.edu). *A posteriori error estimates in finite element exterior calculus.*

We present residual-type a posteriori error estimates for the Hodge Laplace operator within the framework of finite element exterior calculus. The structure of the Hodge Laplace problem leads to some questions which have not been heavily considered in the literature before, especially adaptive approximation of harmonic forms and its effect on the overall error in approximating Hodge Laplace solutions. As a side benefit, we also translate common concepts from residual-type error estimation into the language of differential forms. (Received September 07, 2012)

1086-65-612 **Fred J. Hickernell*** (hickernell@iit.edu), Room E1-208, Dept. of Applied Mathematics, Illinois Institute of Technology, 10 W. 32nd St., Chicago, IL 60616. *Guaranteed Automatic Algorithms for Integration and Function Recovery.*

Numerical libraries contain automatic algorithms, where the work expended is *adaptively* adjusted to the difficulty of the problem, and the answer is provided to within the user-specified error tolerance. Examples include MATLAB's `quad` routine for integration and the `chebfun` toolbox. Often these automatic algorithms perform as advertised, but they can be fooled. In fact, James Lyness argued persuasively in a 1983 SIAM Review article that one could always fool numerical integration algorithms, even with integrands that do not look very strange. This talk presents a framework for automatic numerical algorithms with *rigorous guarantees*, something lacking for nearly all existing automatic algorithms. This framework is illustrated with examples for numerical integration and function recovery. The key is identifying a *cone* of input functions. This departs from typical error analyses that focus on balls of input functions. The algorithms presented here overcome the objections of Lyness because they violate his inherent assumptions. Information-based complexity theory provides sufficient conditions under which adaption does not help. In the setting studied here, these sufficient conditions are violated, and so adaption can, and does, help. (Received September 08, 2012)

1086-65-680 **Fidele F Ngwane***, 807 Hampton street, Walterboro, SC 29488, and **Samuel N Jator**. *Trigonometrically-fitted block hybrid second derivative algorithm for oscillatory problems.*

A continuous hybrid Second Derivative Method (CHSDM) whose coefficients depend on the frequency and stepsize is constructed using Trigonometric basis functions. Some discrete hybrid Second Derivative Methods are recovered from the CHSDM as by-products and applied as a block hybrid Second Derivative Algorithm (BHSDA) to solve oscillatory initial value problems (IVPs). We discuss the stability properties of the BHSDA and present numerical experiments to demonstrate the efficiency of the method. (Received September 11, 2012)

1086-65-723 **Y. Yang*** (yang_yang@brown.edu), 182 George Street, Providence, RI 02912, and **C.-W. Shu**. *Discontinuous Galerkin method for hyperbolic equations involving δ -functions.*

In this talk, we apply discontinuous Galerkin (DG) method for hyperbolic equations involving δ -functions. In general, the numerical solutions are highly oscillatory near the singularities, which we refer to as the pollution region. We first analyze the size of the pollution region and the rate of convergence outside for some model

equations, then apply the method to render-vous algorithms and pressureless Euler equations to show the good performance of the DG method. (Received September 11, 2012)

1086-65-749 **Thanh Tran*** (thanh.tran@unsw.edu.au), School of Maths & Stats, The University of New South Wales, Sydney, NSW 2052, Australia. *Solving geodesic problems on a sphere with spherical splines.*

We discuss the use of spherical splines in solving various equations on a sphere with application in geoscience, namely the Laplace-Beltrami equation, hypersingular integral equation, and shallow water equations. Fast solution techniques will also be discussed. (Received September 12, 2012)

1086-65-792 **Douglas Arnold, Richard Falk, Johnny Guzmán and Gantumur Tsogtgerel*** (gantumur@math.mcgill.ca). *On consistency of the discrete codifferential operators for Whitney forms.* Preliminary report.

In 1976, Dodziuk and Patodi employed Whitney forms to define a combinatorial coderivative operator which is defined on cochains, and they raised the question whether the combinatorial coderivative is consistent in the sense that for a smooth enough differential form the combinatorial coderivative of the associated cochain converges to the exterior coderivative as the triangulation is refined. In 1991, Smits proved this to be the case in two-dimensions assuming that the initial triangulation is refined in a completely regular fashion, by dividing each triangle into four similar triangles. In this work we extend Smits result to arbitrary dimensions, showing that the combinatorial coderivative is consistent for 1-forms if the triangulations possess a large degree of local symmetry. We also show that this restriction on the triangulations is needed, giving a counterexample in which a slightly less regular refinement procedure, namely Whitney's standard subdivision, is used. (Received September 12, 2012)

1086-65-811 **Weizhong Dai*** (dai@coes.latech.edu), Mathematics and Statistics, College of Engineering and Science, Louisiana Tech University, Ruston, LA 71272. *A Generalized Finite Difference Time Domain Scheme for Solving Nonlinear Schrodinger Equation.* Preliminary report.

A novel numerical scheme for solving nonlinear Schrodinger equations is obtained based on the generalized finite-difference time-domain method. The new scheme is shown to satisfy the discrete analogous form of conservation law and is tested by two examples of soliton propagation and collision. Compared with other popular existing methods, numerical results demonstrate that the present scheme provides a more accurate solution. (Received September 13, 2012)

1086-65-814 **Xu Zhang*** (xuz@vt.edu), 460 McBryde Hall, Virginia Tech, Blacksburg, VA 24061. *Solving Planar Elasticity Interface Problems with Cartesian Meshes.*

In the presentation, we will discuss new immersed finite element (IFE) methods for solving the planar elasticity interface problems with Cartesian meshes. Solution meshes in these IFE methods do not need to fit the material interfaces, which can be embedded in the interior of some elements. The IFE basis functions are constructed by incorporating the elastic interface jump conditions. Basic features of these IFE functions and IFE spaces will be discussed. Numerical examples will be provided to demonstrate that these IFE functions maintain the optimal approximation capability, and the IFE solutions for the elasticity interface problem have optimal convergence rates in both energy norm and L^2 norm. (Received September 13, 2012)

1086-65-815 **Qiang Du and Lili Ju***, Department of Mathematics, University of South Carolina, Columbia, SC 29208, and **Li Tian and Kun Zhou.** *A Posteriori Error Analysis of Finite Element Methods for Linear Nonlocal Diffusion and Peridynamic Models.*

In this talk, we present some results on a posteriori error analysis of finite element methods for solving linear nonlocal diffusion and bond-based peridynamic models. In particular, we aim to propose a general abstract framework for a posteriori error analysis of the peridynamic problems. A posteriori error estimators are consequently prompted, the reliability and efficiency of the estimators are proved. Connections between the a posteriori error estimations of the nonlocal problems and that of the related classical partial differential equation based problems are studied within continuous finite element spaces. Some numerical experiments are also given to test the theoretical conclusions. (Received September 13, 2012)

1086-65-817 **Doreen De Leon*** (doreendl@csufresno.edu). *A Wavelet Multigrid Method Using Symmetric Biorthogonal Wavelets.* Preliminary report.

The wavelet multigrid method uses a standard wavelet transform and Schur complements to obtain the necessary coarse grid, interpolation, and restriction operators. A factorized sparse approximate inverse improves

the efficiency of the resulting method. In this presentation, we discuss a modification to the method using symmetric biorthogonal wavelet transforms to define the requisite operators. Numerical examples are presented to demonstrate the effectiveness of this modified wavelet multigrid method for diffusion problems with highly oscillatory coefficients, as well as advection-diffusion equations in which the advection is moderately dominant. (Received September 13, 2012)

1086-65-828 **Thinh T Kieu*** (thinh.kieu@ttu.edu), 4306 16th Street, Quaker Pines Apt#5, Lubbock, TX 79416. *Galerkin Finite Element Method for Semilinear Hyperbolic Equations.*

We study the second order semi-linear hyperbolic equation on bounded domain in $\mathbb{R}^d, d = 2, 3$ with smooth boundary given by

$$u_{tt} - \nabla \cdot (\nabla u) + f(u) = g \text{ with } |f'(u)| \leq C(1 + |u|^p) \quad 0 \leq p \leq \frac{2}{d-2}.$$

We prove that the semidiscrete method conserves the energy. We also establish the improved L^2 -error estimates for our method in both semidiscrete and fully discrete schemes, using the Sobolev-Poincaré inequality and the Gronwall inequality.

(Received September 13, 2012)

1086-65-831 **Weimin Han*** (weimin-han@uiowa.edu), Department of Mathematics, Iowa City, IA 52242. *A Family of Differential Approximations of the Radiative Transport Equation.*

The radiative transport equation (RTE) arises in a variety range of applications in sciences and engineering. It is challenging to solve RTE numerically due to its integro-differential form and high dimension. For highly forward-peaked media, it is even more difficult to solve RTE since accurate numerical solutions require a high resolution of the direction variable, leading to prohibitively large amount of computations. For this reason, various approximations of RTE have been proposed in the literature. This talk is devoted to the introduction and analysis of a family of differential approximations of the RTE. (Received September 13, 2012)

1086-65-893 **Jean M-S Lubuma*** (jean.lubuma@up.ac.za), Dept of Mathematics & Applied Mathematics, University of Pretoria, Pretoria, 0002, South Africa, and **Ronald E Mickens** (rohrsm@math.gatech.edu), Department of Physics, Clark Atlanta University, Atlanta, GA 30314. *Diffusion versus cross diffusion in Biosciences: challenges in designing nonstandard finite difference schemes.*

We consider a class of reaction-diffusion equations the solutions of which enjoy the positivity and boundedness properties. Furthermore, we consider two examples of cross diffusion equations, which have positive solutions. The first example is a model for malignant invasion. The second example is a convective predator-prey pursuit and evasion model. For the class of reaction-diffusion equations, we design nonstandard finite difference (NSFD) schemes that are dynamically consistent with respect to the positivity and the boundedness of solutions. This is achieved by coupling Mickens' rules with a suitable functional relation between the time and the space step sizes. When applied to the two cross diffusion models, it is shown that this approach leads to NSFD schemes which are not dynamically reliable. We then obtain dynamically consistent NSFD schemes for the cross-diffusion models by an alternative strategy which, apart from Mickens' rules, consists in using a special nonlocal approximation of the diffusion terms, the step sizes varying independently from one another. We provide numerical experiments that support the reliability of the NSFD schemes for the relevant continuous models. (Received September 15, 2012)

1086-65-1042 **Xianping Li*** (xianpingl@uca.edu) and **Weizhang Huang** (huang@math.ku.edu). *Discrete maximum principle for the finite element solution of time-dependent anisotropic diffusion problems.*

New results that guarantee the satisfaction of discrete maximum principle (DMP) for anisotropic diffusion problems are presented. Anisotropic diffusion problems arise in the various fields of science and engineering including plasma physics, petroleum engineering, and image processing. The continuous solution satisfies the maximum principle. However, standard numerical methods can produce spurious oscillations when they are used to solve those problems. A common approach to avoid this difficulty is to design a proper numerical scheme and/or a proper mesh so that the numerical solution validates the DMP.

In our research, mesh adaptation via metric specification is applied for the finite element approximation of anisotropic diffusion problems. For stationary problems, "anisotropic non-obtuse angle condition" is developed for a mesh such that the numerical solution is guaranteed to satisfy DMP. This is the first available theoretical results that guarantees the satisfaction of DMP for anisotropic diffusion problems. For time-dependent problems, the conditions for mesh and corresponding time step size are developed to guarantee the satisfaction of DMP. Numerical examples are presented to support the theoretical results. (Received September 18, 2012)

1086-65-1050 **Li Fan***, 656 W. Kirby, 1252 FAB, Detroit, MI 48201, and **Fatih Celiker** and **Zhimin Zhang**. *Hybridizable Discontinuous Galerkin Methods for a Naghdi-type arch model*.

We introduce and analyze Hybridizable Discontinuous Galerkin methods for a Naghdi type arch model. The main feature of these methods is that they can be implemented in an efficient way through a hybridization procedure which reduces the globally coupled unknowns to approximations to the displacement, bending moment and rotation at the element boundaries. Finally, we display extensive numerical results to ascertain the influence of the stabilization parameters on the accuracy of the approximation. In particular, we find specific choices for which all the variables, converge with the optimal order of $k + 1$ when each of their approximations are taken to be piecewise polynomial of degree k . (Received September 18, 2012)

1086-65-1101 **Thomas Strohmer*** (strohmer@math.ucdavis.edu), Department of Mathematics, UC Davis, Davis, CA 94306. *PhaseLift: Exact Phase Retrieval via Convex Optimization*.

Phase retrieval is the problem of reconstructing a function, such as a signal or image, from intensity measurements, typically from the modulus of the diffracted wave. Phase retrieval problems - which arise in numerous areas including X-ray crystallography, astronomy, diffraction imaging, and quantum physics, are notoriously difficult to solve numerically. They also pervade many areas of mathematics, such as numerical analysis, harmonic analysis, algebraic geometry, combinatorics, and differential geometry. In this talk I will introduce a novel framework for phase retrieval, which comprises tools from optimization, random matrix theory, and compressive sensing. I will prove that for certain types of random measurements a signal or image can be recovered exactly with high probability by solving a convenient semidefinite program - a trace-norm minimization problem, without any assumption about the signal whatsoever and under a mild condition on the number of measurements. Our method is also provably stable vis-a-vis noise. I will then discuss how this approach carries over to the classical phase retrieval setting using multiple structured illuminations. Numerical aspects of the proposed approach will be presented and applications to terahertz imaging will be discussed. (Received September 18, 2012)

1086-65-1209 **Roger Telschow***, www.geomathematics-siegen.de. *Iterative Sparse Approximation of Extremely Scattered Data on the Sphere*.

Recent applications often produce highly non-equidistributed data on the sphere. The distribution of such scattered data sets causes several problems which are hardly solvable with the established approximation methods. Whereas the expansion of the signal in a global basis fails for obvious reasons, the use of localizing basis functions, such as spline bases, can also be connected to severe numerical drawbacks. For instance, in case of extremely scattered data, the latter most often yield highly ill-conditioned systems of equations that have to be strongly regularized. We present a novel algorithm based on an orthogonal matching pursuit which iteratively chooses the optimal set of basis functions out of a large redundant dictionary and finds a smooth and sparse solution. We obtain an expansion of the signal which may combine arbitrary spherical basis functions while smoothness is controlled with a certain Sobolev norm. Moreover, the solution is adapted to the detail structure of the signal as well as to the data. Numerical experiments are presented. (Received September 20, 2012)

1086-65-1210 **Volker Michel***, www.geomathematics-siegen.de. *How Mathematics can Help to Observe Climate Change — An Example*.

The Mathematics of Planet Earth 2013 initiative focusses on mathematical methods that enable us to solve the manifold scientific problems that are somehow linked to the Earth. One out of many problems of this kind is an accurate observation of climatic effects such as droughts, floods, El Niño effects, etc. As an example, we show that a novel mathematical method, the Regularized Functional Matching Pursuit, yields a highly accurate reconstruction of water mass transports from gravity data. For instance, seasonal differences in the precipitation and droughts respectively floods can be visualized.

The mathematical background is as follows: We solve an ill-posed inverse problem given by a Fredholm integral equation of the first kind, where large data sets are possible. A regularized version of a greedy algorithm is used to iteratively construct a solution. This solution is combined from global and localized trial functions, where the latter are primarily chosen by the algorithm in areas with a high detail structure. Hence, the obtained solution is sparse in the sense that essentially less trial functions than available are used.

D. Fischer, V. Michel: Inverting GRACE gravity data for local climate effects, Siegen Preprints on Geomathematics, 9, 2012. (Received September 20, 2012)

- 1086-65-1240 **Alfa R.H. Heryudono*** (aheryudono@umassd.edu), Dept of Mathematics, UMass Dartmouth, Dartmouth, MA 02747, and **Elisabeth Larsson** (elisabeth.larsson@it.uu.se), Dept of IT, Uppsala University, 75105 Uppsala, Uppsala, Sweden. *A partition of unity radial basis function collocation method for partial differential equations*. Preliminary report.

For partial differential equations with smooth solutions, radial basis function approximation with infinitely smooth kernels is attractive due to the potentially spectral convergence rates, combined with geometrical flexibility. However, in practice, the success is hampered by ill-conditioning as the problem size grows and as the kernels are made flatter. Furthermore, the computational cost when direct solution methods are used for the arising full linear systems is prohibitive for large-scale problems.

To deal with these issues, we propose a partition of unity approach where radial basis function approximation is employed within each partition. The introduced locality reduces both memory usage and computational cost compared with the global method. However, in order to achieve numerical convergence, we also need stable evaluation of the approximants for nearly flat kernels. This is achieved through employment of the recently developed RBF-QR algorithm [Fornberg, Larsson, and Flyer 2011].

We provide numerical experiments showing spectral convergence with respect to the local problem resolution and algebraic convergence with respect to the partition size. We also discuss the practical implications of the results. (Received September 20, 2012)

- 1086-65-1255 **Daniela Calvetti, Debra McGivney*** (dfm40@case.edu) and **Erkki Somersalo**. *Left and right preconditioning for Electrical Impedance Tomography with structural information*.

Computational inverse problems frequently give rise to linear or nonlinear least squares problems and an effective way to solve such problems is with Krylov subspace iterative methods. We present a computational scheme to be applied to electrical impedance tomography (EIT), a nonlinear, ill-posed inverse problem in which we look to estimate the admittivity distribution inside a body given current/voltage measurements made on the boundary. The problem is addressed in the Bayesian statistical framework with an inner-outer iterative scheme to compute the maximum *a posteriori* estimate with the aid of statistically inspired preconditioners. The right preconditioner arises from a structural prior covariance, while the left preconditioner accounts for the noise, which consists of the assumed measurement error and the modeling error due to a coarse discretization of the problem. The admittivity distribution is updated in the outer iteration and the linearized sub-problem is solved in the inner iteration via conjugate gradient for least squares, with an inexact Newton stopping criterion. Computational efficiency is also addressed in the solution of the forward problem with a finite difference discretization scheme resulting in a fast adjoint method to compute the Jacobian matrix. (Received September 20, 2012)

- 1086-65-1271 **Jehanzeb H Chaudhry*** (jehanzeb.hameed@gmail.com), 101 Weber Building, Colorado State University, Fort Collins, CO 80523, and **Don Estep** (estep@stat.colostate.edu), **Simon Tavener** (tavener@math.colostate.edu) and **Victor Ginting** (vginting@uwoyo.edu). *An a Posteriori Analysis of Iterative Technique for System of Odes*.

We develop an adjoint-based a posteriori analysis for a class of explicit numerical schemes that can involve a fixed-point type iteration of the original system of ordinary differential equations. Contrary to the usual implicit techniques where the adjoint are readily available, there are certain preparatory stages that need to be accomplished before an adjoint is available. The crucial step in this case is on casting the fixed-point type iteration into an implicit-like scheme after which the adjoint equation is derived. The resulting estimator decomposes the error into distinct components like iterative and discretization error. We show results for a variety of problems, including equations with time varying coefficients and partial differential equations. We also apply our analysis techniques to a class of implicit schemes which utilize iterative linear solvers. (Received September 20, 2012)

- 1086-65-1357 **Xin Yang*** (xin.yang@rice.edu), 2410 Shakespeare ST, Unit 102, Houston, TX 77030. *A coupled finite volume and discontinuous Galerkin method for convection-diffusion problems*.

This work formulates and analyzes a new coupled finite volume (FV) and discontinuous Galerkin (DG) method for convection-diffusion problems. DG methods, though costly, have proved to be accurate for solving convection-diffusion problems and capable of handling discontinuous and tensor coefficients. FV methods have proved to be very efficient but they are only of first order accurate and they become ineffective for tensor coefficient problems. The coupled method takes advantage of both the accuracy of DG methods in the regions containing heterogeneous coefficients and the efficiency of FV methods in other regions. Numerical results demonstrate that this coupled method is able to resolve complicated coefficient problems with a decreased computational cost compared to DG methods. This work can be applied to problems such as the transport of contaminant underground, the CO₂ sequestration and the transport of cells in the body. (Received September 21, 2012)

- 1086-65-1386 **Michael L Parks*** (mlparks@sandia.gov), Sandia National Laboratories, P.O. Box 5800, MS 1320, Albuquerque, NM 87185, and **David J Littlewood, John A Mitchell and Stewart A Silling**. *Peridigm: A New Paradigm in Computational Peridynamics*.

Peridynamics is a nonlocal extension of classical continuum mechanics, governed by an integro-differential equation. We survey the state-of-the-art in computational peridynamics by discussing capabilities of the newly available open-source Peridynamics code "Peridigm," discussing the nonlocal computational structure of the code, reviewing discretization techniques and solution methods, and showing demonstration problems. (Received September 21, 2012)

- 1086-65-1414 **Sara N Pollock*** (snpolloc@math.ucsd.edu). *Convergence of goal-oriented adaptive finite element methods for semilinear problems*.

We will discuss a goal-oriented adaptive finite element method for second order semilinear PDEs. In goal-oriented methods we are concerned with approximating a given quantity of interest, a function of the weak solution to the PDE. The adaptive algorithm is driven by estimating the error in both the primal and a dual problem at each iteration. We will discuss the formation of the linearized dual sequence, the limiting dual problem and approximate dual sequence, and how each plays a part in the contraction argument. We will look at the standard contraction framework and discuss some additional estimates used to show convergence in the sense of the quantity of interest. We will also introduce an appropriate notion of error to derive a strong contraction result. Finally we will look at some numerical experiments.

This is joint work with Michael Holst and Yunrong Zhu. (Received September 21, 2012)

- 1086-65-1431 **Susanne C. Brenner, Li-yeng Sung and Yi Zhang*** (yzhang24@math.lsu.edu), 103 Lockett Hall, Department of Mathematics, Baton Rouge, LA 70803. *A Quadratic C^0 Interior Penalty Method for an Elliptic Optimal Control Problem with State Constraints*.

We consider a second order elliptic optimal control problem with state constraints on convex polygonal domains. We will present theoretical and numerical results for a quadratic C^0 interior penalty method that solves the optimal control problem numerically as a fourth order variational inequality. This is joint work with Susanne C. Brenner and Li-yeng Sung. (Received September 21, 2012)

- 1086-65-1481 **Wenyuan Liao*** (wliao@ucalgary.ca), Department of Mathematics and Statistics, 2500 University of Calgary, Calgary, Alberta T2N1N4, Canada. *On the stability and accuracy of a fourth-order Rosenbrock method for semi-linear parabolic differential equation*.

It is known that the semi-discrete ordinary differential equation system resulting from spatial discretization of a parabolic equation, for instance, the heat equation, is highly stiff. Therefore numerical methods with stiff stability such as implicit Runge-Kutta methods are preferred to solve the ODE system. However those methods are usually computationally expensive, especially for nonlinear problems. Rosenbrock method, a subclass of implicit Runge-Kutta method, is efficient since it is iteration-free for nonlinear problem, but suffers from order reduction, when applied to nonlinear parabolic problems. In this paper we constructed a fourth-order Rosenbrock method to solve the semi-linear parabolic partial differential equation in 1-D supplemented with Dirichlet and Neumann boundary conditions. It has been shown that the Rosenbrock method is strongly A-stable hence is suitable for the stiff ODE system obtained from compact finite difference discretization of the reaction-diffusion equation. We also shown that the new method is free of order reduction when applied to nonlinear parabolic problem. Several numerical experiments have been conducted to demonstrate the efficiency, stability and accuracy of the new algorithm. (Received September 25, 2012)

- 1086-65-1525 **Chen Greif** (greif@cs.ubc.ca), Department of Computer Science, University of British Columbia, Vancouver, B.C. V6T 1Z4, Canada, **Tyrone Rees** (tyrone.rees@stfc.ac.uk), Department of Scientific Computing, STFC Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshir OX11 0QX, United Kingdom, and **Daniel B Szyld*** (szyld@temple.edu), Department of Mathematics, Temple University (038-16), 1805 N. Broad Street, Philadelphia, PA 19122-6094. *MPGMRES: a generalized minimum residual method with multiple preconditioners*.

Standard Krylov subspace methods only allow the user to choose a single preconditioner, although in many situations there may be a number of possibilities. Here we describe an extension of GMRES that allows the use of more than one preconditioner. We make some theoretical observations, propose a practical algorithm, and present numerical results from problems in domain decomposition and PDE-constrained optimization. Our results illustrate the applicability and potential of the proposed approach. (Received September 23, 2012)

- 1086-65-1536 **James V Lambers*** (james.lambers@usm.edu), 118 College Dr #5045, Hattiesburg, MS 39406-0001. *Approximate Diagonalization of Variable-Coefficient Differential Operators Through Similarity Transformations*. Preliminary report.

Approaches to approximate diagonalization of variable-coefficient differential operators using similarity transformations are presented. These diagonalization techniques are inspired by the interpretation of the Uncertainty Principle by Fefferman, known as the *SAK* Principle, that suggests the location of eigenfunctions of self-adjoint differential operators in phase space. The similarity transformations are constructed using canonical transformations of symbols and anti-differential operators for making lower-order corrections. Numerical results indicate that the symbols of transformed operators can be made to closely resemble those of constant-coefficient operators, and that approximate eigenfunctions can readily be obtained. (Received September 23, 2012)

- 1086-65-1626 **Gregory T Minton*** (gminton@math.mit.edu), 77 Massachusetts Ave, Cambridge, MA 02139. *Rigorous Numerical Methods for Gravitational Orbits*.

There is a configuration of three masses which, under Newtonian gravity, chase each other around a figure-eight orbit. This striking result, first numerically discovered by Cris Moore, is an example of an “ n -body choreography”. While some choreographies have rigorous existence proofs — for instance, Chenciner and Montgomery proved existence of the figure-eight orbit — proof techniques have lagged behind numerical evidence. In this talk, we will first explain the numerical action-minimization methods and show, by live demonstration, that it is surprisingly easy to find interesting choreographies. We will then present a method, based on an effective form of Newton’s method, for converting these numerical results into fully rigorous computer-assisted proofs. Put together, this procedure lets one automatically convert a picture into a theorem! We will conclude with some other applications of this computer proof technique. (Received September 23, 2012)

- 1086-65-1632 **Leszek Demkowicz, Jay Gopalakrishnan*** (gjay@pdx.edu) and **Joachim Schoeberl**. *Polynomial extension operators*.

We constructively prove the existence of polynomial extension operators in three fundamental Sobolev spaces on a tetrahedron. To describe the result in the Sobolev space $H(\text{div})$, suppose w is a function on the boundary of a tetrahedron such that it is a polynomial of degree at most p on each face. Then, we construct an operator E such that (i) Ew is a vector function whose components are polynomials of at most the same degree p in the tetrahedron, (ii) Ew an extension of w in the sense that the trace of the normal component of Ew on the boundary of the tetrahedron coincides with w , and (iii) E extends to a continuous operator from a natural trace space into $H(\text{div})$. Similar results hold for the other two Sobolev spaces (namely $H(\text{grad})$ and $H(\text{curl})$) that completes a well-known exact sequence. (Received September 23, 2012)

- 1086-65-1635 **Yifan Zhang*** (yifan_zhang@brown.edu), 182 George Street, Providence, RI 02912, **Xiangxiong Zhang** (zhangxx@mit.edu), Department of Mathematics, Massachusetts Institute of Technology, Cambridge, MA 02139, and **Chi-Wang Shu** (shu@dam.brown.edu), 182 George street, Providence, RI 02912. *Maximum-principle-satisfying second order discontinuous Galerkin schemes for convection-diffusion equations on triangular meshes*.

In this talk, second order accurate discontinuous Galerkin (DG) schemes which satisfy a strict maximum principle for general nonlinear convection-diffusion equations on unstructured triangular meshes will be proposed. We prove that under suitable time step restriction for forward Euler time stepping, for general nonlinear convection-diffusion equations, a simple scaling limiter coupled with second order DG methods preserves the physical bounds indicated by the initial condition while maintaining uniform second order accuracy. The limiters are mass conservative and easy to implement. We extend the schemes to SSP high order time discretizations and two dimensional convection-diffusion equations on triangular meshes. There are no geometric constraints on the meshes such as angle acuteness. Numerical results including incompressible Navier-Stokes equations will be presented. (Received September 23, 2012)

- 1086-65-1683 **Hongkai Zhao*** (zhao@math.uci.edu), Irvine, CA 92617. *Quantitative photoacoustic imaging*.

I will present two recent works for quantitative photoacoustic imaging. Photoacoustic is a hybrid imaging modality that can achieve ultrasound resolution for optical contrast. Quantitative photoacoustic imaging includes two key steps. In the first step, one has to solve an inverse source problem for the acoustic wave to reconstruct initial acoustic source distribution from boundary measurements. We present a Neuman series based iterative algorithm that can recover the initial wave field efficiently and accurately. The second step is to reconstruct optical properties of the medium using internal measurements, namely, using the reconstructed initial acoustic source distribution from the first step. We propose a hybrid reconstruction procedure that uses both interior

measurement and boundary current data, which is usually available in diffuse optical tomography. (Received September 24, 2012)

1086-65-1685 **Minah Oh***, Department of Mathematics and Statistics, 305 Roop Hall, MSC 1911, James Madison University, Harrisonburg, VA 22807. *A New Approach to the Finite Element Analysis of Axisymmetric Problems.*

Three-dimensional axisymmetric problems can be reduced to a two-dimensional (2D) problem via cylindrical coordinates. This is an attractive feature, since it reduces computational time significantly. The difficulty is that the analysis of the resulting 2D problem involves weighted Sobolev spaces where the weight function is the radial component r . In this talk, we will discuss a new approach to the finite element analysis of axisymmetric problems: FEEC (Finite Element Exterior Calculus). In particular, we will discuss the axisymmetric Hodge Laplacian. The construction of bounded cochain projections in appropriate weighted spaces is the key idea. (Received September 24, 2012)

1086-65-1689 **Thomas A Goldstein*** (tomgold2@gmail.com), 3627 25TH ST., San Francisco, CA 94110. *Improved Alternating Direction Methods for Numerical Optimization.*

Alternating direction methods are an important class of algorithms for solving large-scale optimization problems, especially in the field of image processing. In this talk, we explore new ways of improving conventional alternating direction schemes. These include techniques for accelerating convergence, and adaptive timestepping. (Received September 24, 2012)

1086-65-1723 **Richard S. Falk and Ragnar Winther*** (ragnar.winther@cma.uio.no). *Local bounded cochain projections.* Preliminary report.

We construct projections from $H\Lambda^k(\Omega)$, the space of differential k forms on Ω which belong to $L^2(\Omega)$ and whose exterior derivative also belongs to $L^2(\Omega)$, to finite dimensional subspaces of $H\Lambda^k(\Omega)$ consisting of piecewise polynomial differential forms defined on a simplicial mesh of Ω . Thus, their definition requires less smoothness than assumed for the definition of the canonical interpolants based on the degrees of freedom. Moreover, these projections have the properties that they commute with the exterior derivative and are bounded in the $H\Lambda^k(\Omega)$ norm independent of the mesh size h . Unlike some other recent work in this direction, the projections are also locally defined in the sense that they are defined by local operators on overlapping macroelements, in the spirit of the Clément interpolant. (Received September 24, 2012)

1086-65-1727 **Michael Neilan*** (neilan@pitt.edu), 302 Thackeray Hall, Pittsburgh, PA 15260, and **Richard S. Falk and Johnny Guzmán.** *Conforming and divergence-free Stokes elements.*

In this talk, we discuss three families of conforming finite elements for the two dimensional Stokes problem that produce exactly divergence-free approximations on very general triangulations. The construction of these elements is guided by two discrete smoothed de Rham complexes ("Stokes complexes"). Extensions to the three dimensional setting will also be discussed. (Received September 24, 2012)

1086-65-1748 **Snorre H Christiansen*** (snorrec@math.uio.no), CMA c/o Dept. Math., University of Oslo, PO Box 1053 Blindern, NO-0316 Oslo, Norway. *Finite element systems of differential forms and applications to upwinding.*

The notion of a finite element system is designed to provide an alternative to Ciarlet's definition of a finite element, adapted to the needs of exterior calculus. It allows for cellular decompositions of space (rather than just simplexes or products thereof) and general functions (rather than just polynomials) yet guarantees compatibility with the exterior derivative and existence of commuting interpolation operators. We review basic definitions and properties. As an application we show how a form of upwinding, compatible with the exterior derivative, can be carried out within this framework.

references:

S. H. Christiansen, H. Z. Munthe-Kaas, B. Owren. Topics in structure-preserving discretization. Acta Numer. 20 (2011), 1-119.

S. H. Christiansen. Upwinding in finite element systems of differential forms. Smale lecture, Proceedings of FoCM 2011, to appear. (Received September 24, 2012)

- 1086-65-1763 **Prince Chidyagwai*** (chidyagp@temple.edu), Department of Mathematics, 638 Wachman Hall, 1805 N. Broad Street, Philadelphia, PA 19122, and **Benjamin Seibold, Martin Frank** and **Philipp Monreal**. *Discontinuous Galerkin method for the M_1 moment closure model for radiative transfer*.

Radiative transfer plays an important role in many engineering and physics applications. We consider the radiative transport equation applied to electron radiotherapy. In this case the transport equation describes the distribution of electrons in time and space assuming that the electrons do not interact with each other. The full radiative transfer equation is computationally expensive to solve because it is a high dimensional equation. We consider the minimum entropy approximation to the radiative transfer equation using the Discontinuous Galerkin method. The numerical schemes provide an approximation to the particle distribution which must remain positive. We present a positivity preserving numerical scheme, convergence results and benchmark test cases for problems in radiative therapy simulations. (Received September 24, 2012)

- 1086-65-1783 **Keith J Wojciechowski*** (wojciechowskik@uwstout.edu), University of Wisconsin-Stout, 202D Jarvis Hall Science Wing, 410 10th Avenue East, Menomonie, WI 54751, and **Kristian Sandberg**. *The EPS Method: A New Method for Constructing Pseudospectral Differential Operators*.

In this talk we demonstrate new types of derivative matrices for pseudospectral methods. The norm of these matrices grows at the optimal rate $\mathcal{O}(N^2)$ for N-by-N matrices in contrast to standard pseudospectral constructions that result in $\mathcal{O}(N^4)$ growth of the norm. The smaller norm offers an advantage when using the derivative matrix for solving time dependent problems. The construction is based on representing the derivative operator as an integral kernel composed of singular functions so the matrices naturally incorporate the boundary conditions of the problem and do not rely on the interpolating polynomials. We provide numerical results for the new construction and demonstrate that the construction achieves similar or better accuracy than traditional pseudospectral derivative matrices, while resulting in a norm that is orders of magnitude smaller than the standard construction. To demonstrate the advantage of the new construction, we apply the method for solving a variety of linear and nonlinear PDEs in both rectangular and polar geometries. (Received September 24, 2012)

- 1086-65-1809 **Holger Heumann*** (hheumann@unice.fr), LJAD, Université de Nice - Sophia Antipolis, Parc Valrose, 06100 Nice, France. *Hyperbolic Problems with Involutions and Discrete Differential Forms*.

A linear, first order differential equation with homogeneous righthand side is an *involution* of some given hyperbolic conservation law if both equations have the same solution. Very often, the involution is considered to be a very important geometric structure of the conservation law, for instance the vanishing divergence of the magnetic field for Maxwell equations. As a consequence, much effort has been devoted to devising finite volume schemes that compute numerical solutions that are, at least approximatively, solution of some discrete version of the involution as well.

If, as for the Maxwell equations, the differential operator of the involution is an exterior derivative, we could simply use discrete differential forms for the discretization of the conservation laws. Then the solution fulfills the involution exactly. But, the non-standard localization of the degrees of freedom of discrete differential forms are a considerable obstruction for the extension of existing finite volume codes. We would like to illuminate how the framework of discrete differential forms can nevertheless help to devise finite volume schemes for which a corresponding *discrete involution* follows naturally. (Received September 24, 2012)

- 1086-65-1842 **Douglas N. Arnold** and **Daniele Boffi*** (daniele.boffi@unipv.it), Dipartimento di Matematica "F. Casorati", Via Ferrata 1, 27100 Pavia, PV, Italy, and **Francesca Bonizzoni**. *Approximation properties of tensor product finite element differential forms*. Preliminary report.

It is well known that standard quadrilateral (resp. hexahedral) finite elements are constructed starting with a given finite dimensional space on a square (resp. cubic) reference element and then transformed to the actual element via a bilinear (resp. trilinear) isomorphism of the square (resp. cube) onto the element. The approximation properties of the above spaces depend on the reference space and on the considered transformation.

We discuss the abstract construction of tensor product of complexes of differential forms. This allows in a natural way the definition of shape functions and degrees of freedom for finite element differential forms of order k on cubes in n dimensions. This construction can be extended via the pullback transformation to curvilinear cubic elements, obtained as images of a reference cube. In this context we study the approximation properties of the resulting finite element spaces. When the maps from the reference cube are affine, the approximation rate depends only on the degree of polynomials contained in the reference space; in the more general case, when the

maps are multilinear, a degradation in the approximation rate is observed, the loss being more severe for higher degree differential forms. (Received September 24, 2012)

1086-65-1891 **Gunay Dogan*** (gunay.dogan@nist.gov). *Shape Reconstruction from Direct and Indirect Measurements.*

Detection and reconstruction of shapes from sensor measurements is important to many areas of science and engineering. Examples are tracking cell shapes in automated microscopy images, delineation of tumor boundaries from computed tomography sinograms, or identification of grains in material micrographs. In this talk, I will introduce a numerical framework that enables us to compute and characterize shapes, such as sets of curves in 2d or surfaces in 3d, explicitly from given images or other indirect measurements. For this, I will formulate the shape reconstruction problem as an energy minimization task and then describe the numerical components to realize the minimization in an efficient and reliable manner. I will demonstrate the effectiveness of the method with several examples. (Received September 24, 2012)

1086-65-1942 **Ari Stern*** (astern@math.wustl.edu) and **Paul C. Leopardi.** *The abstract Hodge–Dirac operator and its stable discretization.*

Most of the recent work on finite element exterior calculus has focused on the second-order Laplace operator and its variants, including the Laplace–Beltrami operator on a Riemannian manifold, the Hodge–Laplace operator for differential forms, and—most general of all—the abstract Hodge–Laplace operator on a Hilbert complex. By comparison, Dirac operators have received relatively little attention from the perspective of numerical PDEs, despite the fact that these first-order operators are, in many ways, just as fundamental as the Laplace operators mentioned above.

In this talk, we introduce an abstract Hodge–Dirac operator and analyze its discretization by mixed finite elements. This is shown to have a deep connection with discrete Hodge theory, and in fact, many of the theorems on the Hodge–Laplace operator in finite element exterior calculus are shown to be corollaries of these new results. (Received September 24, 2012)

1086-65-1964 **Peter Blomgren*** (blomgren.peter@gmail.com), Department of Mathematics and Statistics, San Diego State University, 5500 Campanile Dr, San Diego, CA 92182. *Developing a "light-weight" skin cancer image screening system.*

Telemedicine is designed to help resolve disparities in health resource distribution. One of the critical factors for the success is access to high quality medical information, mostly in resource-limited settings. We use a modified light-field digital camera to acquire high-quality surface images, and develop computational image processing tools to aid skin cancer screening and diagnosis. (Received September 24, 2012)

1086-65-2011 **James B Collins*** (jbcoll12@gmail.com), **Don Estep** and **Simon Tavener.** *A posteriori error estimates for explicit time integration methods.*

In this work we consider a posteriori error analysis of approximations of ordinary differential equations obtained via an explicit finite difference method. Two classes of finite difference methods are considered. An equivalent finite element scheme is derived to allow for this analysis. The error representation formula is separated into various contributions, each corresponding to a different type of approximation used in the method. Numerical results are given to demonstrate the accuracy of the error estimator and an example of adaptivity. (Received September 24, 2012)

1086-65-2035 **Andrew Gillette*** (akgillette@mail.ucsd.edu), Department of Mathematics, UC San Diego, 9500 Gilman Drive MC 0112, La Jolla, CA 92093. *Geometric Decomposition of Serendipity Finite Element Spaces.*

I will first introduce new Hermite-style and Bernstein-style geometric decompositions of the cubic order serendipity finite element spaces $\mathcal{S}_3(I^2)$ and $\mathcal{S}_3(I^3)$, as defined in the recent work of Arnold and Awanou [*Found. Comput. Math.* **11** (2011), 337–344]. The cubic serendipity spaces are substantially smaller in dimension than the more commonly used tensor product spaces - 12 instead of 20 for the square and 32 instead of 64 for the cube - yet are still guaranteed to obtain cubic order *a priori* error estimates when used in finite element methods. The basis functions in these new decompositions have a number of nice properties, including canonical relationships to the finite element degrees of freedom and to the geometry of their graphs. I will conclude by showing how this approach for cubics can be extended to construct decompositions for both higher polynomial order and higher form order serendipity spaces. (Received September 24, 2012)

- 1086-65-2096 **Muhammad Usman*** (musman1@udayton.edu), 300 College Park, Dayton, OH 45469-2316, and **Giacomo Flora** and **Christopher Yakopcic**. *A Numerical Study and Stability Analysis of a Model for In Vitro Inhibition of Cancer Cell Mutation*. Preliminary report.

Human homeostasis is the body's ability to physiologically regulate its inner environment to ensure its stability in response to changes in the outside environment. An inability to maintain homeostasis may lead to death or disease, which is caused by a condition known as homeostatic imbalance. Normal cells follow the homeostasis when they proliferate and cancer cells do not. This work describes a model consisting of three reaction-diffusion equations representing in vitro interaction between two drugs. One inhibits proliferation of cancerous cells, and the other destroys these cells. The growth of in-vitro cancer cells has been studied using two numerical methods: the Predictor-Corrector and the Operator Splitting method. A stability analysis of the model is performed with and without diffusion applied to the model. MATLAB is used to perform the stability analysis of the model. (Received September 24, 2012)

- 1086-65-2103 **Nathan Dunfield** and **Anil N. Hirani*** (hirani@cs.illinois.edu), 201 N. Goodwin Avenue, Urbana, IL 61801. *Computing analytic torsion*.

We'll describe our experiences with numerically computing analytic torsion for surfaces and hyperbolic 3-manifolds using finite element exterior calculus. (Received September 24, 2012)

- 1086-65-2278 **T G Halvorsen*** (toregha@gmail.com), University Of Oslo, Department of Mathematics, 0316 Oslo, Norway, and **S H Christiansen** and **T M Sorensen**. *"Structure preserving discretization of the Yang-Mills equation"*.

"In this talk we will introduce the variational form of the SU(n) Yang-Mills equation(s). Then we will show how the action, from which the equation(s) stem, can be discretized in a symmetry preserving way on simplicial meshes, using Whitney forms and parallel transport. Numerical results will be provided." (Received September 25, 2012)

- 1086-65-2287 **Jeffrey S Ovall*** (jovall@ms.uky.edu), Lexington, KY 40506, and **Hengguang Li** (hli@math.wayne.edu), Detroit, MI. *A posteriori estimation of hierarchical type for the Schrödinger operator with inverse square potential on graded meshes*.

We develop an *a posteriori* error estimate for mixed boundary value problems of the form $(-\Delta + V)u = f$, where the potential V may possess inverse-square singularities at finitely many points in the domain. We prove that our error estimate can be efficiently computed and is equivalent to the actual error in the energy norm on a family of geometrically graded meshes appropriate for singular solutions of such problems. Therefore, our estimate can be used for a practical stopping criterion. A variety of numerical experiments support our theoretical results. We also offer a direct convergence and effectivity comparison between the geometrically-graded meshes, which are based on *a priori* knowledge of possible singularities in the solution, and adaptively refined meshes driven by local error indicators associated with our *a posteriori* error estimate. (Received September 25, 2012)

- 1086-65-2299 **Douglas N. Arnold*** (arnold@umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455. *Unisolvency in the finite element exterior calculus*.

This talk will focus on the verification of unisolvency for finite element spaces in the finite element exterior calculus. A finite element is defined by specifying, for each element, a space of shape functions and a set of degrees of freedom. The degrees of freedom must be unisolvent, that is, they must form a basis for the dual of the shape function space. The verification of unisolvency often guides the construction of finite elements. While this has been an important part of finite elements since the beginning, the finite element exterior calculus has led to many new families of finite elements and unified many of the existing one, and, in particular, has clarified the approaches to unisolvency. (Received September 25, 2012)

- 1086-65-2375 **Jeffrey M Connors*** (connors4@llnl.gov). *Quantification of operator splitting effects in finite volume calculations of advection-diffusion*.

Some issues are presented involving splitting effects in operator-split finite volume calculations for advection-diffusion. In applications, it is desirable to understand the errors and sources of errors in calculations, such as splitting effects, which may be difficult to determine. One approach is presented for a *a posteriori* error estimation to calculate the error in a quantity of interest (QoI) and investigate the effect of the splitting on the computed QoI value. The details of the error budget are useful to inform uncertainty quantification studies and to help with code verification as well as code optimization. (Received September 25, 2012)

- 1086-65-2404 **Andrea L Bertozzi*** (bertozzi@math.ucla.edu), 520 Portola Plaza, Los Angeles, CA 90095, Los Angeles, CA 90095, and **Ekaterina Merkurjev** and **Tijana Kostic**. *An MBO scheme on graphs for segmentation and image processing.*

We present a computationally efficient algorithm utilizing a fully or semi-nonlocal graph Laplacian for solving a wide range of learning problems in data clustering and image processing. Combining ideas from L1 compressive sensing, image processing and graph methods, the diffuse interface model based on the Ginzburg-Landau functional was recently introduced for solving problems in data classification. Here, we propose an adaptation of the classic numerical Merriman-Bence-Osher (MBO) scheme for graph-based methods and also make use of fast numerical solvers for finding eigenvalues and eigenvectors of the graph Laplacian. We present various computational examples to demonstrate the performance of our model, which is successful on images with texture and repetitive structure due to its nonlocal nature. (Received September 25, 2012)

- 1086-65-2413 **Katharine F Gurski*** (kgurski@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059. *A Simple Construction of Nonstandard Finite Difference Schemes Applied to SIR Problems.*

We have developed a simple and solid mathematical construction for nonstandard finite difference (NSFD) schemes using standard differential equation approximation techniques such as introducing artificial viscosity. While NSFD schemes have been employed to calculate numerical solutions to difficult nonlinear differential equations to machine precision, these schemes are not used by the bulk of mathematicians and scientists. Currently the technique needed to define a NSFD scheme for a particular differential equation requires extensive physical insight into the behavior of the modeled entity and has not been extended to general systems of nonlinear differential equations. We extend the analysis of Erdogan and Ozis by presenting a construction for second order nonlinear autonomous functions that constructs the numerator and denominator functions for Mickens' equivalent schemes. We extend this result to systems of up to three differential equations and demonstrate the advantages on applications using SIR models. (Received September 25, 2012)

- 1086-65-2431 **Selin Sariaydin*** (sxs9473@rit.edu), School of Mathematical Sciences, Rochester, NY 14623, and **Baasansuren Jadamba** (bxjsma@rit.edu), 85 Lomb Memorial Drive, Rochester, NY 14623. *Extragradient Methods for Inverse Problems*. Preliminary report.

In this talk, we will study the inverse problem of identifying the coefficient of the fourth order boundary value problems. Several known extragradient methods will be discussed to compare the numerical results. (Received September 25, 2012)

- 1086-65-2435 **Erin R Crossen*** (erc7690@rit.edu), 1198 Judge Rd, Basom, NY 14013, **Akhtar Khan** (aaksma@rit.edu), NY, and **Baasansuren Jadamba** (bxjsma@rit.edu), NY. *Equation Error Approach for the Inverse Problem of Tumor Identification*. Preliminary report.

Equation error approach was used to recover variable Lamé parameters of incompressible material. This problem can be applicable to identifying tumors in the human body due to the human body's near incompressibility and the differing stiffness in tumors. Numerical results will be presented. (Received September 25, 2012)

- 1086-65-2441 **Nathan Bush*** (ncb2494@rit.edu), **Akhtar A Khan**, **Fabio Raciti** and **Baasansuren Jadamba**. *Identification of a Variable Parameter in Fourth-Order Partial Differential Equations by an Equation Error Approach.*

The method of equation error is employed to identify a variable parameter in the fourth-order partial differential equations. A smooth regularization is used to identify smooth parameters and the BV-seminorm regularization is used to identify discontinuous coefficients. Existence and convergence results are given for the equation error approach. Finite element based numerical experiments show the effective of the considered approach. The effect of data smoothing is shown for the noisy data. (Received September 25, 2012)

- 1086-65-2478 **R. C. Harwood*** (rhawood@georgefox.edu) and **V. S. Manoranjan**. *Oscillation-Free Stability Analysis for Linear and Semilinear Diffusion Equations.*

Techniques for developing oscillation-free numerical methods will be presented. Stability conditions for numerical solutions to linear diffusion equations may allow damped oscillatory behavior. While still stable, these oscillations can be removed by applying additional oscillation-free conditions to make the numerical solution more realistic. In semilinear diffusion equations, where a nonlinear reaction term is added, oscillatory behavior may create instabilities for certain reaction terms. Oscillation-free conditions will be presented from various approaches including Von Neumann analysis, monotonicity restrictions, and operator splitting techniques. (Received September 25, 2012)

- 1086-65-2497 **Lina Ma*** (ma6@purdue.edu), 150 N. University Street, West Lafayette, IN 47906. *3D Maxwell equations on Exterior Problem.*

We study the time-harmonic Maxwell equations on exterior problem, using transferred field expansion which turns the problem with exterior of a regular sphere. We perform spherical harmonic analysis on tangential plan and use Legendre-Galerkin spectral method on radius direction. This high order method is efficient and accurate, which can be easily extended to multi-domain scattering. (Received September 25, 2012)

- 1086-65-2566 **Adnan H Sabuwala*** (asabuwala@csufresno.edu). *Spectrally Matched Grids: Anisotropy and Semi-Infinite Spectral Intervals.*

Traditional finite-difference techniques using uniform grids for numerical solution of PDE's are slow and compute the solution over the entire problem domain. However, for receiver-targeted applications such as geophysical exploration, one wishes to compute faster solutions to PDE's at specific receiver locations with high accuracy. Spectrally matched non-uniform grids have been shown to achieve super exponential convergence for such problems. In this talk, we give an introduction to the method of computing spectrally matched grids. We then use these grids to compute solutions to anisotropic problems. We also introduce a new set of non-uniform grids called Remes grids and exhibit their convergence. These grids can be used to solve problems over semi-infinite spectral intervals such as with a delta function signal source. Numerical experiments have been conducted and their results presented in this talk. (Received September 25, 2012)

- 1086-65-2636 **Mayla R Boguslav*** (mrb2227@columbia.edu), New York, NY 10027, and **Overtoun Jenda**. *The Solution to the 3-Variable Frobenius Number Problem.* Preliminary report.

Given a set of relatively prime positive integers a_1, a_2, \dots, a_n , after some point all positive integers are representable as a linear combination of the set with nonnegative coefficients. The last integer that is not so representable is the Frobenius Number, and finding that number is the Frobenius problem or coin problem. While the two-variable solution is widely known, and the general solution is NP-hard, there have been several algorithmic solutions of the three-variable problem. Here we present a formulaic solution for the Frobenius number of all relatively prime triples, and a graphic representation of such. (Received September 25, 2012)

- 1086-65-2637 **Maarten de Hoop**, IN, **Lingyun Qiu*** (qiu@purdue.edu), 150 N. University St, West Lafayette, IN 47906, and **Otmar Scherzer**. *A multi-level projected steepest descent iteration for nonlinear inverse problems in Banach spaces subject to stability constraints.*

We consider a class of inverse problems defined by a nonlinear map from parameter or model functions to data. The parameter functions and data are contained in certain Banach spaces. Assuming conditional stability of the inverse problem, that is, assuming that stability holds on a closed, convex subset of the domain of the operator, we introduce a novel nonlinear projected steepest descent iteration and analyze its convergence to an approximate solution given limited accuracy data. We proceed with developing a multi-level algorithm based on a nested family of closed, convex subsets on which stability holds and the stability constants are ordered. Growth of the stability constants is coupled to the increase in accuracy of approximation between neighboring levels to ensure that the algorithm can continue from level to level until the iterate satisfies a desired discrepancy criterion, after a finite number of steps. (Received September 26, 2012)

- 1086-65-2640 **Blanca Ayuso de Dios*** (bayuso@crm.cat), Centre de Recerca Matemàtica, Campus de Bellaterra, 08193 Barcelona, Catalunya, Spain, and **Franco Brezzi, L. Donatella Marini, Jinchao Xu** and **Ludmil T. Zikatanov**. *A simple preconditioning strategy for a class of DG-H(div)-conforming methods for the Stokes problem.*

We construct a family of Discontinuous Galerkin methods for the Stokes problem where the velocity field is $H(\text{div}; \Omega)$ -conforming. This implies that the velocity solution is divergence-free in the whole domain. This property can be exploited to design a simple and effective preconditioning strategy for the final linear system. Both the construction of the methods and the preconditioner, as well as the analyses of both, are done in an abstract framework using some of the basic ingredients of Finite Element Exterior Calculus (FEEC). (Received September 25, 2012)

- 1086-65-2642 **John A. Evans*** (evans@ices.utexas.edu) and **Thomas J. R. Hughes**. *Isogeometric Discrete Differential Forms with Application to Viscous Fluid Flow.*

In this talk, we will discuss a new class of discrete differential forms that is motivated by the recent emergence of isogeometric analysis. The cornerstone of this technology is the definition of spline spaces that constitute a discrete de Rham complex and associated commuting projection operators. Then, following the isogeometric paradigm, these spaces and operators are mapped onto NURBS- and T-spline-based geometries. Isogeometric discrete differential forms can be immediately applied to problem classes where the existence of a discrete de

Rham diagram is a key ingredient for stability. For example, they can be used to obtain correct approximation of Maxwell eigenvalues. Moreover, as a result of their high levels of smoothness, isogeometric discrete differential forms can be applied to problem classes characterized by enhanced regularity. Namely, they can be directly utilized in the Galerkin solution of viscous flow problems using primitive variables. In the context of incompressible flows, this results in discrete velocity fields which are point-wise divergence-free. We will discuss both the construction of isogeometric discrete differential forms and their various mathematical properties as well as their application to the Brinkman and incompressible Navier-Stokes equations. (Received September 25, 2012)

1086-65-2659 **Michael D Bice*** (mbice@csustan.edu), Mathematics Department, California State University, Stanislaus, 1 University Circle, Turlock, CA 95380. *A Multigrid Method for One-Dimensional Systems of Hyperbolic Conservation Laws*. Preliminary report.

We develop a multigrid method for numerically solving one-dimensional systems of hyperbolic conservation laws. This method uses any stable conservative scheme as the base scheme upon which the multigrid techniques are built. A restriction operator transfers data from the finest grid to coarser grids. We use linear interpolation on the differences of the numerical fluxes to move information from coarser grids to the finest grid. Our multigrid method requires fewer operations and hence less CPU time to reach a given stopping time than the base scheme. We provide many numerical examples to illustrate both the stability of the multigrid method and the advantages of using this method. (Received September 25, 2012)

1086-65-2663 **Stefan M Wild*** (wild@mcs.anl.gov), Mathematics and Computer Science Division, Bldg 240, 1154, Argonne, IL 60439. *Optimal Derivatives of Noisy Simulations*.

Computational noise in deterministic simulations is as ill-defined a concept as can be found in scientific computing. Roundoff errors, discretizations, numerical solutions to systems of equations, and adaptive techniques can destroy the smoothness of the processes underlying a simulation. Such noise complicates optimization, sensitivity analysis, and other applications that depend on the simulation output.

We present a new method for estimating the computational noise that arises in virtually all numerical HPC simulations. We use an estimate of the computational noise to address a longstanding problem in derivative estimation: How should finite-difference parameters be determined when working with a noisy function? Our near-optimal parameters are easy to compute and come with provable approximation bounds. (Received September 25, 2012)

1086-65-2748 **Abdramane Serme*** (aserme@bmcc.cuny.edu), 199 Chambers Street, New York, NY 10007, and **Jean W. Richard** (jrichard@bmcc.cuny.edu), 199 Chambers Street, New York, NY 10007. *Solving an Ill Conditioned Linear System using the Extended Iterative Refinement Algorithm: The Convergence Theorem*.

Many numerical analysts assume the convergence of the (extended) iterative refinement algorithm. We consider the linear system $CW = U$ where W is the unknown matrix. We use the following extended iterative refinement algorithm to solve for W :

$$\begin{aligned} W_0 &= C_0^{-1}U_0 \quad (U_0 = U \text{ and } C_0 = C + F_0) \\ W_k &= (C + F_k)^{-1}U_k \\ U_{k+1} &= U_k - CW_k + E_k \\ X_k &= W_0 + W_1 + \dots + W_k, \text{ for } k = 0, 1, 2, \dots \end{aligned}$$

The goal of this talk is to show that the above extended iterative refinement algorithm converges by providing a theorem that we called the theorem of convergence of the (extended) iterative refinement. The convergence of the iterative refinement is a central issue when solving ill conditioned linear systems. To compute the accurate solution $x = A^{-1}b$ of an ill conditioned linear system $Ax = b$ we use the Schur aggregation method and the Sherman-Morrison-Woodbury (SMW) formula $A^{-1} = C^{-1} + C^{-1}U(I - V^H C^{-1}U)^{-1}V^H C^{-1}$. The Schur aggregate $S = I - V^H C^{-1}U$ is computed using the extended iterative refinement. The talk will also cover the notion Additive Preconditioner UV^H and when the A -modification $C = A + UV^H$ is well conditioned. (Received September 25, 2012)

1086-65-2877 **L. Chen***, 510F Rowland Hall, University of California at Irvine, Irvine, CA 92697, **L.P. Chen**, Sun Yat-Sen University, Guangzhou, Guangdong, Peoples Rep of China, **M. Wang**, Peking University, Beijing, Beijing, Peoples Rep of China, and **J. Xu**, Department of Mathematics, Pennsylvania State University, University Park, PA 16801. *Discretization using $H(\text{curl})$ element for the Biot model*.

The Biot model of poroelasticity has been widely used in petroleum engineering, acoustic wave propagation in saturated media, and biology for several decades. In this talk, we present a novel $H(\text{curl})$ element discretization

of the Biot model. The divergence operator applied to edge element is understood in the weak sense and the Laplacian operator is discretized using mixed formulation. The resulting discretization is solver-friendly in the sense that an efficient multigrid solver can be developed based on the underlying exact sequence. Numerical examples are provided to show the proposed method is efficient for the poroelasticity simulation.

This is a joint work with Luoping Chen, Ming Wang, and Jinchao Xu. (Received September 25, 2012)

1086-65-2965 **Jeffrey W Banks, Jeffrey M Connors*** (connors4@llnl.gov), **Jeffrey A Hittinger** and **Carol S Woodward**. *The Error Transport and Adjoint Methods of Numerical Error Estimation*.

We will discuss two methods to estimate discretization errors. Error transport methods seek to estimate entire fields of error by deriving evolution equations for the error and then numerically approximating the solution. Adjoint methods seek to estimate the error in a functional measurement of the (primal) solution. This is accomplished by deriving an equation for the error in the measurement that involves projections of local residuals for the primal solution onto the solution of an adjoint problem.

An important consideration for *a posteriori* error estimation methods is their performance on PDEs for problems that involve weak solution features or other degeneracies. Typically, the errors in such regions are large. For nonlinear problems, the nonlinear behavior in the error field must be resolved in these regions when using the error transport method. On the other hand, when using the adjoint method with a measurement that is sensitive to weak primal solution features, there will be regions where the adjoint solution must be well-resolved. To test the error estimation techniques, we have formulated and will discuss several problems based on linear and nonlinear hyperbolic PDEs, nonlinear, parabolic PDEs with degeneracies and advection-diffusion. (Received September 26, 2012)

1086-65-2972 **Richard K Archibald*** (archibaldrk@ornl.gov), Oak Ridge National Laboratory, One Bethel Valley Road, P.O. Box 2008, MS-6301, Oak Ridge, TN 37831-6367. *Scalable adaptive function approximation and error estimation for stochastic simulations*.

Stochastic collocation methods are an attractive choice to characterize uncertainty because of their non-intrusive nature. High dimensional stochastic spaces can be approximated well for smooth functions with sparse grids. There has been a focus in extending this approach to non-smooth functions using adaptive sparse grids. We have developed a fast method that can capture piecewise smooth functions in high dimensions with high order and low computational cost. This method can be used for both approximation and error estimation of stochastic simulations where the computations can either be guided or come from a legacy database. We compare these methods to more traditional statistical approaches. (Received September 26, 2012)

1086-65-2973 **David Kan*** (dkan@comsol.com), Comsol, Inc., 10850 Wilshire Boulevard, Suite 800, Los Angeles, CA 90024. *State of the Art in Multiphysics Simulation*.

Simulation of physical processes has come a long way since the Manhattan Project. In fact, the capabilities of today's simulation software is keeping up and even exceeding the pace of hardware development. This talk will offer an insider perspective of the current status of multiphysics environments including user interface/experience, physics (i.e., equation) implementation, solver architecture, and results processing. (Received September 26, 2012)

1086-65-2974 **Egil Bae*** (ebae@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90025. *Convex Variational Models and Efficient Optimization Algorithms for Image Segmentation*.

Many of the most successful mathematical models for image segmentation and other partition problems are formulated as variational or discrete optimization problems. These problems are typically non-convex or NP-hard, which poses fundamental difficulties from a computational point of view. This is especially the case if the number of regions is larger than two, or if unknown region description parameters are part of the optimization problem. In this talk, I will present convex formulations and relaxations of such problems, which are later used to develop very efficient optimization algorithms. Under certain conditions, the algorithms are guaranteed to converge to a global minimum of the original problems. The conditions can in some cases be checked in advance based on the input data and otherwise be checked after computation. Even if they are not met exactly, it is demonstrated that close approximations to global minima can be obtained. (Received September 26, 2012)

1086-65-2978 **M. Zuhair Nashed*** (zuhair.nashed@ucf.edu). *Weakly Bounded Noise and Applications to Regularization of Ill-Posed Operator Equations and Moment Discretization*.

The standard view of noise in ill-posed problems is that it is either deterministic and small (strongly bounded noise) or random and large (not necessarily small). A new noise model was recently proposed and investigated by

Eggermont et al. (see [1] and [2]), wherein the noise is weakly bounded. Roughly speaking, this means that the "local averages" of the noise are small. In this talk we describe the mathematical setting of this approach and give a precise definition in a Hilbert space setting. We give applications to regularization theory and moment discretization problems such as those that arise in geophysical problems and other inverse problems when the data are available at a discrete set of points. [1] P.P.B. Eggermont, V. N. LaRiccia and M. Z. Nashed, *Inverse Problems*, 25(2009)115018 (14 pages); [2] -, *Noise Models for Ill-Posed Problems*, in "Handbook of Geomathematics" (W. Freeden, M. Z. Nashed and T. Sonar, Eds.), pages 741-762, Springer-Verlag, 2010; [3] -, *Moment discretization for ill-posed problems with discrete weakly bounded noise*, *GEM: International Journal on Geomathematics*, published online: 9 April 2012; vol.3(2012), to appear. (Received September 26, 2012)

1086-65-2980 **M. Zuhair Nashed*** (zuhair.nashed@ucf.edu). *Bounded Variation Regularization Revisited: Mathematical Aspects*. Preliminary report.

Based on joint research with Otmar Scherzer, we consider some mathematical aspects dealing with convergence and stability of minimization problems in the space of functions of bounded variation. Examples include BV denoising, BV regularization of least-squares solutions of ill-posed operator equations, and nonstandard minimization problems arising in conductivity imaging. (Received September 26, 2012)

1086-65-2987 **Jeffrey Humphreys*** (jeffh@math.byu.edu), 275 TMCB Brigham Young University, Provo, UT 84602, and **Robert M. Panoff** (rpanoff@shodor.org), Shodor, 807 E. Main Street, Suite 7-100, Durham, NC 27701. *Coursework and Programs in Applied and Computational Mathematics at the University Level*. Preliminary report.

In the recent PCAST report "Engage to Excel", a call was made to increase the number of STEM graduates by 34 (Received September 27, 2012)

1086-65-2989 **Cory Hauck*** (hauckc@ornl.gov), Computer Science and Mathematics Division, Oak Ridge National Laboratory, 1 Bethel Valley Road, Bldg. 6012, Oak Ridge, TN 37831-6367. *Optimization-based moment closures for kinetic equations*. Preliminary report.

We discuss the formulation and implementation of optimization tools for deriving moment closures in kinetic equations. (Received September 27, 2012)

1086-65-2990 **Robert R. Muise*** (robert.r.muise@lmco.com), Lockheed Martin Missiles and Fire Control, 5600 Sand Lake Rd, Orlando, FL 32819. *Optimal measurement kernel for wide-area compressive imaging*. Preliminary report.

For applications involving imaging very large areas with high resolution the traditional pixel-sensing of standard cameras becomes prohibitive. Compressive sensing offers an alternative sensor design for which information is sensed rather than pixels. Sparse models are then applied to a reconstruction operator to visualize the sensed imagery. Significant theoretical results exist which guarantee image reconstruction for the case when the sensing kernels are randomized. We present an alternative viewpoint for sensing kernel design which optimizes the reconstruction quality. (Received September 27, 2012)

1086-65-2994 **George Fann*** (fanngi@ornl.gov), Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, FL 37831-6367. *Computational Harmonic Analysis and Cauchy Problems*. Preliminary report.

We describe the constructive approximations of time-dependent Green's functions and its applications for solving Cauchy problems in high dimensions using massively parallel computers, with examples from computational physics. (Received October 01, 2012)

1086-65-2996 **Sadasivan Shankar*** (sadasivan.shankar@intel.com), Intel Corporation, Design and Technology Solutions, 2200 Mission College Blvd., Santa Clara, California. *Role of mathematics in solving industrial problems: semiconductor materials & chemistry*. Preliminary report.

The talk will cover how modeling of complex systems help in not only giving insight, but also directions for enabling practical solutions. (Received October 02, 2012)

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1086-68-304 **olive n. mbianda*** (611, E.Park st, apt 103, Carbondale, IL 62901, and **henry hexmoor**. *modeling a building evacuation*.

abstract evacuation process is a set of actions, engaged to ensure human safety in an emergency situations. the main purpose of evacuation is to have people moved from risky locations to safe ones, in a minimum amount of time. since catastrophes cannot be predicted, the challenge is in anticipating problems that may occur, especially those related to human behavior. many evacuation models have been developed, in order to help minimize the evacuation time and maximize the number of rescues. to reach these goals, there are many factors that should be taken into account when developing such models. among these factors are occupant's characteristics and types of relation among them, building architecture (characteristics) and nature or type of emergency. we will see how a variation on one (or many) of these factors would affect the outcome of the evacuation (evacuation time, number of rescues). therefore, it will help us to develop suitable evacuation models for a variety of buildings.

keywords: crowd, crowd behavior, emergency, exit, social interactions. (Received August 17, 2012)

1086-68-404 **JM Landberg*** (jml@math.tamu.edu), Department of Mathematics, Texas A&M University, Mailstop 3368, College Station, TX 77843-3368. *On the complexity of matrix multiplication*.

I will discuss new lower bounds for the rank and border rank of matrix multiplication and the relationship of the study to representation theory and classical objects in algebraic geometry such as Darboux hypersurfaces. (Received August 29, 2012)

1086-68-412 **Shrawan Kumar*** (shrawan@email.unc.edu), Department of Mathematics, UNC at Chapel Hill, Chapel Hill, NC 27599-3250. *A study of the representations supported by the orbit closure of the determinant*. Preliminary report.

We will study a class of representations which are supported by the orbit closure of the determinant and also the permanent. (Received August 30, 2012)

1086-68-518 **Rodney G Downey*** (rod.downey@vuw.ac.nz), School of Mathematics, Statistics, and Operat, Victoria University PO Box 600, Wellington, 6140, New Zealand. *Parameterized Complexity Overview*.

Parameterized complexity is a widely applied methodology of coping with computational intractability. It works by containing combinatorial explosions by limiting parameters, and the result is an extended dialog with the problem at hand. This dialog uses a rich positive toolkit combined with various completeness programs. The result is that modulo certain complexity assumptions, we can even have optimal running times for algorithm s, at least up to an O factor. This talk will give a brief survey of the area with an eye towards areas of mutual interest between the incremental and multivariate groups. (Received September 05, 2012)

1086-68-547 **Peter J. Olver*** (olver@umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455. *Invariant histograms and signatures for object recognition and symmetry detection*.

I will survey recent developments in the use of group-invariant histograms, using distances, areas, etc., and signatures, using differential invariants, joint invariants, invariant numerical approximations, etc., for object recognition and symmetry detection in images, including recent applications to jigsaw puzzle assembly. (Received September 06, 2012)

1086-68-742 **Christie Quaranta*** (caquaranta@plymouth.edu), **Imanol Arrieta Ibarra**, **Eric Schwartz** and **Elena Sizikova**. *Improving Cross-lingual Search Quality*.

Advancements in Information Retrieval (IR) focus primarily on increasing the speed and accuracy of search upon large data collections. One branch of IR is Cross-Language Information Retrieval (CLIR). With so many different languages across the world, it is imperative to be able to search in several languages effectively. Most CLIR methods involve machine translation; however automated translators are still very imprecise. Our research presents eight methods for cross-lingual search on the Shoah Foundation Institute Visual History Archive, as well as metrics to analyze the effectiveness of each method. We used the standard definitions of precision and recall, as well as a third metric, the F-measure, which is a weighted harmonic mean of the first two. First, a method in which the entire thesaurus is translated and searched is compared to another method SQTm to determine, which technique yields superior results. Moving forward with the more-effective SQTm, we improved recall and precision, and studied the methods for merits and downfalls. Recall-improving techniques presented involve

expanding each search query to more “related” terms, while precision-improving methods utilize context-based filtering to narrow-down search queries by weeding out “irrelevant” ones. (Received September 11, 2012)

1086-68-757 **Andrew M Childs**, **David Gosset*** (dngosset@gmail.com) and **Zak Webb**. *Universal computation by multi-particle quantum walk*.

Multi-particle quantum walk includes well-known physical systems of interacting particles on graphs, such as the Bose-Hubbard model and models with nearest-neighbor interactions. We show how multi-particle quantum walk can efficiently simulate a universal quantum computer. In principle, our construction provides an architecture for a quantum computer which does not require time-dependent control. (Received September 12, 2012)

1086-68-824 **Robert Erbacher**, Army Research Lab, **Trent Jaeger**, Penn State University, **Nirupama Talele**, Penn State University, and **Jason Teutsch*** (teutsch@cse.psu.edu), Penn State University. *On the fixed-parameter tractability of Lattice Cut with applications to network security*. Preliminary report.

Preventing security vulnerabilities before they occur, as opposed to patching them once revealed by an attack, remains an outstanding problem in computer security. We propose an automated, proactive security program for maintaining data integrity across a distributed system. One may interpret the components of a distributed system as nodes in a directed graph with edges indicating which components can communicate directly with others. Some information traveling through the system will have high integrity, and other information will have lower integrity, and we wish to keep these types separated. To this end we identify in the graph a set of “terminal” nodes representing the possible attack surfaces for the system, and each terminal corresponds to a specific integrity level as measured by a finite poset. Given such a graph with distinguished terminals and a poset, how many edges must we cut, or “mediate,” in order to prevent illegal information flows across the system? We show that when the poset is a total ordering, we can find an optimal solution for this problem in polynomial time parameterized in both the cut size and number of terminals. The more general case is equivalent to Directed Multicut and thus remains a distinguished open problem. (Received September 23, 2012)

1086-68-915 **Petr Hliněný*** (hlineny@fi.muni.cz), **Robert Ganian** and **Jan Obdržálek**. *On an odd case of an XP algorithm for graphs of bounded clique-width*.

The “Myhill-Nerode-like” approach to designing FPT algorithms on tree-like decompositions (say, of graphs), pioneered by [Abrahamson-Fellows], has been proved very useful since. One can sometimes even use the same approach in the infinite-index case; when the number of the respective congruence classes (of the input problem) grows only polynomially with the input size. In a lucky case, one then gets an XP algorithm, but this is not automatic since one has to provide a polynomial algorithm replacing the transition function of an automaton from a finite case, too.

Complementing a stream of successful applications of this principle, we show one very odd case - of the minLOB (min-leaf outbranching) problem on digraphs of bounded clique width. Although it is relatively straightforward to prove that the number of minLOB congruence classes on graphs with a fixed number of labels is at most polynomial, by a suitable refinement, it is also clear that the classes of this refinement cannot be rigorously combined together. Yet, a more complicated XP algorithm along these lines exists. See details in the full paper <http://dx.doi.org/10.4230/LIPIcs.STACS.2011.404>. We suggest to further investigate this strange phenomenon which we do not fully understand yet. (Received September 16, 2012)

1086-68-954 **Neil D. Jones*** (neil@diku.dk). *Towards relating program transformation, incremental computation and parameterized complexity*. Preliminary report.

The aim of *partial evaluation* is automatically to speed up a program p with two inputs s and d (static and dynamic) by *specialising* p to a known value of s . Speedup owes to *removal of subcomputations depending only on s* . Typically linear speedup, with coefficient depending on the value of s , and large enough to be of practical interest.

Partial evaluators (also self-applicable) exist for programming languages Scheme, Prolog and C. Applications: optimisation; compiling and compiler generation from programming language interpreters. Emphasis is on automation (no human interaction).

Supercompilation and distillation: automatic transformations on the call-by-name lambda calculus (+ constructors and recursive function definitions). Well-quasi orders are a key technique to ensure that transformation terminates. Distillation can yield superlinear speedup, by eliminating repeated subcomputations.

Incremental computation can yield still greater speedups by reusing repeated subcomputations, but is less automatic.

Anticipated: a correspondence between “binding times” central to partial evaluation, optimisations done in incremental computation, and the order in which problem parameters are given for parameterized complexity. (Received September 17, 2012)

1086-68-1027 **Volker Diekert*** (diekert@fmi.uni-stuttgart.de), Universitaetsstrasse 38, 70569 Stuttgart, Germany. *Logspace computations in graph products*. Preliminary report.

We will show that certain group theoretic decision problems are robust under taking graph products in terms of logspace computability. Elder, Elston and Ostheimer asked if the word problem of a free product of groups having a logspace normal form is again in logspace. A solution was given for linear groups. Waack showed that the word problem of the free product $G * H$ is NC^1 reducible to the word problem of G, H and the free group on two generators. Therefore the question can be answered positively. We generalize this result to graph products of arbitrary groups with a word problem in logspace using Bass-Serre theory.

If moreover, in addition to the word problem, a normal form of the vertex groups can be computed in logspace, then we are able to compute normal forms in the graph product in logspace. (Received September 18, 2012)

1086-68-1072 **Dan E Willard*** (dew@cs.albany.edu). *On the Linear and Quasi-Linear CPU Time for Most Relational Calculus and Data Mining Queries Using $O(N)$ Space*.

Let Q denote a relational calculus or data mining query that seeks to search an unindexed set of size I to produce an output of size U . This talk will define a subset of relational calculus queries of this type, called RCS, that has the property that every RCS query runs in time $O(U + \log^d I)$ where the exponent d is a constant that depends on the query (and which usually equals zero or one).

A result of this type was previously announced by us in two stages in year 1996 and 2002 articles in the Journal of Computer and System Sciences. During those times, our results may have seemed mostly theoretical because their $O(U + \log^d I)$ CPU time and $O(I+U)$ space would have appeared prohibitively expensive (on account of mostly the amount of main memory space used). A theme of our current talk is that these algorithms are now very tempting in the context of the 4G bytes that most modern computers have available.

The current talk will both review our prior results and explore the main open questions that they raise. (These include examining RCS queries from a more parameterized perspective.) (Received September 19, 2012)

1086-68-1136 **Moshe Y. Vardi*** (vardi@cs.rice.edu), Rice University MS-132, 6100 Main Street, Houston, TX 770051892. *Database Queries - Logic and Complexity*.

Mathematical logic emerged during the early part of the 20th Century, out of a foundational investigation of mathematics, as the basic language of mathematics. In 1970 Codd proposed the relational database model, based on mathematical logic: logical structures offer a way to model data, while logical formulas offer a way to express database queries. This proposal gave rise to a multi-billion dollar relational database industry as well as a rich theory of logical query languages.

This talk will offer an overview of how mathematical logic came to provide foundations for one of today's most important technologies, and show how the theory of logical queries offer deep insights into the computational complexity of evaluating relational queries. (Received September 19, 2012)

1086-68-1245 **J Kuodo Huang*** (jkuodo@gmail.com), P. O. Box 3355, Alhambra, CA 91803. *My strategy versus Kurt Gödel's strategy To the solution of Hilbert second problem*. Preliminary report.

Kurt Gödel has had many contributions to logic and has influenced many subfields in logic, mathematics and computer science. His main strategy to Hilbert second problem based on paradox and had shown the limit of logic. However my strategy to the solution of Hilbert second problem is to eliminate all the paradoxes and has discovered Hilbert logic (which is any extension of two-valued logic so that the universal consistent theorem can be proved). As matter of fact, there are many complete Hilbert logics. In this article, I will give the comparison of “Kuodo's strategy versus Kurt's strategy to the solution of Hilbert second problems” in detail. The Hilbert logic can be considered as exploring the limits of logic from “the logic as deductive systems” to “logic as systems to all types of logic systems” because Hilbert logic is integrated logic with set theory in various ways. (Received September 23, 2012)

1086-68-1291 **Michael Fellows*** (michael.fellows@cdu.edu.au), **Rodney Downey** (rod.downey@msor.vuw.ac.nz), **Annie Liu** (liu@cs.stonybrook.edu) and **Anil Nerode** (anerode1@twcny.rr.com). *Summary and Future Directions Discussion*.

This session will be a summary and future directions discussion led by the panel Rod, Mike, Annie and Anil and perhaps others. (Received September 20, 2012)

1086-68-1505 **Andrew D Drucker*** (adrucker@math.ias.edu), *On the AND- and OR-Conjectures: Limits to Efficient Preprocessing.*

One of the major insights of fixed-parameter tractability theory is that for many *NP*-hard problems, it is possible to efficiently *shrink* instances which have some underlying simplicity. This preprocessing can be a powerful first step toward solving such instances.

At the same time, many other *NP*-hard problems have resisted efficient preprocessing. The “AND-” and “OR-conjectures” of Bodlaender, Downey, Fellows, and Hermelin (JCSS 2009) gave a unified explanation of the hardness of many such problems. Since their work, an important goal has been to provide more standard complexity-theoretic evidence for these conjectures. I will describe recent progress in this area and, time permitting, discuss possible directions for future research.

Based on the paper “New Limits to Classical and Quantum Instance Compression.” (Received September 22, 2012)

1086-68-1517 **Vikraman Arvind*** (arvind@imsc.res.in), Institute of Mathematical Sciences, CIT Campus, Taramani, Chennai, 600113, India. *Parameterized Complexity and Permutation Group Problems.*

The impact of parameterized complexity on graph algorithms, and its interplay with graph minor theory is a great success story. It is natural to explore this in other problem domains like group-theoretic and number-theoretic computation.

We consider permutation group problems. There are several permutation group problems, e.g., Set Stabilizer and Coset Intersection, with a similar status as Graph Isomorphism: the best-known algorithms are over 30 years old with running time $n^{O(\sqrt{n})}$. This calls for an application of the parameterized complexity paradigm!

Interesting natural parameters for permutation groups already exist. E.g., *the minimum base size, the composition width, the separation number, the orbit size* of a permutation group. Let $G \leq S_n$ be a permutation group and X and Y be n -vertex graphs. We say X and Y are G -isomorphic if some $\pi \in G$ maps X to Y . If G has composition-width k then checking if X and Y are G -isomorphic is in $n^{O(k)}$. Hence, the problem is in XP but we do not know if it is in the W-hierarchy or W[P]. If G has orbit size k , then the same problem is in FPT. Does this problem have polynomial size kernels? We discuss such questions, give some answers, and leave many open problems. (Received September 23, 2012)

1086-68-1532 **Andrey Rukhin*** (andrey.rukhin@navy.mil), NSWC-DD, Dahlgren, VA 22448-5161. *Heuristics in the p -post Tower of Hanoi Problem.*

New heuristics for search are introduced for the p -post ($p \geq 3$) Tower of Hanoi problem. This method, based on two results covered in the talk, may 1. prune the potential search space and 2. given a sequence connecting two arbitrary configurations, reduce the number of moves required to connect the configurations. Recent efforts have conducted other heuristic-based searches of the state space of disk configurations with $p = 4$ posts (e.g., Korf and Felner, 2007); the proposed heuristics, which apply for all $p \geq 3$, can be included with these pre-existing approaches to further verify the optimality of the Frame-Stewart solution. (Received September 23, 2012)

1086-68-1571 **Yanhong Annie Liu*** (liu@cs.stonybrook.edu), Computer Science Department, State University of New York at Stony Brook, Stony Brook, NY 11794. *Incrementalization: From Clarity to Efficiency.*

Two major concerns of study rest at the center of computer science: what to compute, and how to compute efficiently. Problem solving involves going from clear specifications for the “what” to efficient implementations for the “how”. This is challenging because, usually, clear specifications correspond to straightforward implementations, not at all efficient, while efficient implementations are difficult to understand, not at all clear.

This work gives an overview of a systematic method for transforming clear specifications into efficient implementations via incrementalization. The method has three steps: (1) iterate—determine a minimum increment to be taken repeatedly, (2) incrementalize—maintain appropriate values incrementally over the repeated steps, and (3) implement—design data structures for the values maintained. We illustrate the method through examples, taken from problems in hardware design and image processing expressed using loops and arrays, in query processing and access control expressed using set expressions, in sequence processing and math puzzles expressed using recursive functions, in program analysis and trust management expressed using logic rules, and in building software components expressed using objects. Finally we discuss future directions. (Received September 23, 2012)

1086-68-1680 **Ioannis Koutis***, ioannis.koutis@upr.edu. *Algebraization in parameterized algorithms and complexity.*

We survey recent advances in parameterized algorithms based on algebraization techniques: reductions to fundamental parameterized problems on multivariate polynomials. We also discuss how limitations of algebraic methods, implied by parameterized complexity, can reveal beautiful mathematical facts. (Received September 24, 2012)

1086-68-1681 **Ulrike Stege*** (stege@cs.uvic.ca), Department of Computer Science, University of Victoria, Victoria, BC V8W 3P6, Canada. *Applying Parameterized Complexity to Cognitive Science.*

We discuss the role of parameterized complexity in cognitive science, highlighting two aspects. First, when explaining cognitive processes such as decisions, cognitive scientists often use models formulated as optimization problems. Many such problems are computationally intractable (NP-hard), although the cognitive processes they model are expected to be "cognitively tractable". The cognitive-science community often employs heuristics to explain this apparent disconnect. A heuristic does not provide evidence to prove or refute a particular model. Parameterized complexity analysis can lead to the identification of the sources of intractability. This in turn can lead to the rejection or refinement of such models. We present computational problems that are discussed in the literature as models for cognitive processes, including Subset Choice and Coherence. Second, when investigating the human problem solving capabilities for computationally hard problems, many experiments discussed in the literature indicate a very good human performance on such problems. Again, often explanations in the literature rely on heuristics. We discuss on the example of Vertex Cover how tractable parameterizations and fixed-parameter algorithms can help to shed light on such results. (Received September 24, 2012)

1086-68-1687 **S E Venegas-Andraca*** (sva@mindsomexico.org), Ap. postal 12-808 Narvarte, 03001 Mexico City, Mexico. *Quantum walk-based Mathematical Morphology Operators.* Preliminary report.

Image Processing is a pervasive and cross-disciplinary field of computer science and engineering that focuses on storing, manipulating and retrieving visual information in computer systems. Image processing is a most important discipline in many branches of science and engineering (e.g. astrophysics, pattern recognition, medical diagnosis and oil extraction) due to our constant and increasing need to extract information out of images and videos.

Due to the restricted architecture of classical computers and the often overwhelming computational complexity of state-of-the-art classical algorithms in image processing, finding efficient algorithms to manipulate visual information is an important research area in this field. Quantum Image Processing, an emergent field of quantum computation, is a discipline devoted to the development of novel (and faster) quantum algorithms for storing, processing and retrieving visual information.

Mathematical Morphology is a scientific field, based on set and lattice theories, devoted to analysing and processing structures contained in images. In this talk we shall present a quantum-walk based version of fundamental mathematical morphology operators. (Received September 24, 2012)

1086-68-1691 **Francesca Rapetti*** (frapetti@unice.fr), Laboratoire Dieudonne, Universite de Nice, Parc Valrose, 06108 Nice, France. *A simple construction of high-order Whitney forms.*

Low-order Whitney elements are widely used for electromagnetic field problems. Higher-order approximations are receiving increasing interest, but their definition remains unduly complex. In this paper we propose a new simple construction for Whitney p-elements of polynomial degree higher than one that use only degrees of freedom associated to p-chains. We provide a basis for these elements on simplicial meshes and give a geometrical localization of all degrees of freedom. Properties of the higher-order Whitney complex are deeply investigated. (Received September 24, 2012)

1086-68-1714 **Christian Ikenmeyer*** (ciken@math.upb.de). *Geometric Complexity Theory and Tensor Rank.* Preliminary report.

Mulmuley and Sohoni (GCT1 in SICOMP 2001, GCT2 in SICOMP 2008) proposed to view the permanent versus determinant problem as a specific orbit closure problem and to attack it by methods from geometric invariant and representation theory. At STOC 2011, Bürgisser and Ikenmeyer showed that these ideas can be adopted towards the goal of proving lower bounds on the border rank of specific tensors, in particular for matrix multiplication. Since then, significant progress in this direction has been made, which we want to present. (Received September 24, 2012)

- 1086-68-1804 **Sepp Hartung** and **Rolf Niedermeier*** (rolf.niedermeier@tu-berlin.de), FG AKT, Sekr. TEL 5-1, Ernst-Reuter-Platz 7, TU Berlin, D-10587 Berlin, Germany. *Incremental List Coloring of Graphs, Parameterized by Conservation.*

Incrementally k -list coloring a graph means that a graph is given by adding vertices step by step, and for each intermediate step we ask for a vertex coloring such that each vertex has one of the colors specified by its associated list containing some of in total k colors. We introduce the “conservative version” of this problem by adding a further parameter c specifying the maximum number of vertices to be recolored between two subsequent graphs (differing by one vertex). The “conservation parameter” c models the natural quest for a modest evolution of the coloring in the course of the incremental process instead of performing radical changes. We show that even on bipartite graphs the problem is NP-hard for $k \geq 3$ and W[1]-hard for an unbounded number of colors when parameterized by c . In contrast, also on general graphs the problem becomes fixed-parameter tractable with respect to the combined parameter (k, c) . Furthermore, we present some results with respect to kernelization and investigate the parameterized complexity on various subclasses of perfect graphs. Finally, we provide empirical findings on the practical relevance of our approach in terms of an effective graph coloring heuristic. (Received September 24, 2012)

- 1086-68-1851 **Joshua A. Grochow*** (jgrochow@cs.toronto.edu), Dept. of Computer Science, University of Toronto, 10 King's College Road, Rm.3302, Toronto, ON M5S 3G4, Canada. *Matrix Lie algebra isomorphism and symmetry-characterization in Geometric Complexity Theory.*

The Matrix Lie Algebra Isomorphism problem asks whether two Lie algebras of $n \times n$ matrices, given by bases, are conjugate by an invertible $n \times n$ matrix. This problem arises naturally in Geometric Complexity Theory (GCT) in attempting to understand the orbits of symmetry-characterized functions such as the permanent and determinant from a computational perspective. (A function is symmetry-characterized if it is the only function that is stabilized by its stabilizer.) We show that Matrix Isomorphism for abelian diagonalizable matrix Lie algebras is at least as hard as Graph Isomorphism, and for semisimple matrix Lie algebras is equivalent to Graph Isomorphism. The complexity of Graph Isomorphism, in turn, is a long-standing open question. For the special cases of Lie algebras that arise from the determinant or matrix multiplication, we show that the Matrix Lie Algebra Isomorphism problem can be solved in polynomial time. This leads to an efficient computational understanding of these orbits, for example: testing whether a function f lies in the orbit of the determinant can be done in polynomial time. This latter connection relies crucially on the symmetry-characterization of the determinant. We also discuss more generally the role of symmetry-characterization in GCT. (Received September 24, 2012)

- 1086-68-1876 **Ryan Williams*** (rrw@cs.stanford.edu), Computer Science Department, Stanford University, 353 Serra Mall, Stanford, CA. *Parameterized Algorithms and Circuit Lower Bounds.*

This talk is concerned with two topics: (a) parameterized algorithms for circuit satisfiability, which slightly improve on the obvious brute force algorithm, and (b) non-uniform circuit lower bounds.

It has been suggested that (a) should be a relatively simple and esoteric task, while (b) is one of the primary objectives in the theory of computational complexity. In 2010, we proved that, in a very broad sense, (a) *implies* (b). Last year, we developed new algorithms for satisfiability of ACC circuits, which led to proofs of non-uniform ACC lower bounds. (More precisely, we proved that $\text{NEXP} \not\subseteq \text{ACC}/\text{poly}$, which had been open for 20 years.) A key piece of the puzzle is an algorithm for rapidly evaluating any large ACC circuit on all of its possible satisfying assignments, a task that seems related to incremental algorithms.

This talk will give an overview of these new developments. (Received September 24, 2012)

- 1086-68-1884 **Minh P. Nguyen*** (mpn051000@utdallas.edu) and **Yan Cao** (yan.cao@utdallas.edu). *Shape Classification Using Diffeomorphic Deformation of Contours.*

Shape classification is a problem of fundamental importance in computer vision and pattern recognition. Given a set of shapes, the goal is to put similar shapes into the same categories. The challenge is how to define “similarity” between shapes. Some shapes which are similar in an intuitive sense can be extremely difficult (or impossible) for computer to recognize. We propose a new shape comparison method based on diffeomorphic deformation of contours.

Given a binary image of a shape, we consider the largest contour extracted from the image. We then define a shape signature based on diffeomorphic deformation from a common shape (such as circles) to the particular contour. Geometric properties such as distances, tangent vectors and curvatures are used when defining the shape signature. This approach is scalable to large data sets by avoiding pair-wise matching of contours directly.

The experimental results on commonly used binary shape databases are discussed. (Received September 24, 2012)

1086-68-2140 **Neil Immerman*** (immerman@cs.umass.edu), 140 Governors Drive, Amherst, MA 01002.
Synthesis of Dynamic Algorithms. Preliminary report.

I will talk about work in progress to automatically go from a description of a property in logic to a dynamic algorithm that checks whether an input satisfies the property. (Received September 24, 2012)

1086-68-2348 **Peter W Shor*** (shor@math.mit.edu), Room 2-362, MIT, 77 Mass. Ave, Cambridge, MA 02482. *Recent Developments in Quantum Information*.

When considered in the light of quantum mechanics, both the theory of computation and the theory of information undergo considerable changes. We will discuss some recent developments in these areas. (Received September 25, 2012)

1086-68-2727 **Jason Meltzer*** (jasonm1@gmail.com), 1055 E Colorado Blvd, Suite 340, Pasadena, CA 91106. *Computer Vision for Robotics in the Home, Factories, and Space*.

Robotics has advanced rapidly into many aspects of life, including the home, workplaces, the military, and space exploration. Facilitating this growth is our understanding of vision-based sensing, which allows robots to operate safely and efficiently in the real world. Depending on the application, a robot may need to navigate the environment, find, recognize, and manipulate objects, track targets, or interact with humans or other robots. Computer vision techniques, including structure from motion, object/category recognition, detection, and pose estimation support these tasks. This talk will focus on these of computer vision algorithms and their underlying mathematical and statistical methods. (Received September 25, 2012)

1086-68-2893 **Sam F Tannouri***, Computer Science Department, Morgan State University, 1700 E. Cold Spring, Baltimore, MD 21215, and **Ahlam E Tannouri**, Mathematics Department, Morgan State University. *3D Graphs With Augmented Perception*.

The need for tools and algorithmic techniques to deal with very large graphs structures representing massive communication data is emerging to become one the fundamental areas of research. In our work, we are trying to enhance the visualization of graphs; we had proposed the "confluent graphs" to reduce the number of links between the nodes by joining together several links in one flow; then we proposed to convert 2D graphs to 3D, and now we are trying to use the "Stereoscopic techniques" to increase the clarity while viewing 3D graphs. Stereoscopy, also called stereoscopic or 3-D imaging, refers to a technique for creating or enhancing the illusion of depth in an image by presenting two offset images separately to the left and right eye of the viewer. These two-dimensional images are then combined in the brain to give the perception of 3-D depth. We are planning to rewrite, and present the use of one passive stereoscopic technique that uses two-color-glasses to improve the quality of vision of very dense graphs. If our experiment turns well we will improve this work by using the active shutter glasses in our future research. Sponsored By CCICADA The Command, Control, and Interoperability Center for Advanced Data Analysis (Received September 26, 2012)

1086-68-2907 **Douglas R Smith*** (smith@kestrel.edu), 3260 Hillview Avenue, Palo Alto, CA 94304.
Formal Coalgebraic Specifications and their Refinement.

The Specware system developed at Kestrel Institute supports formal specification of software requirements via structured presentation of theories in classical higher-order logic. It also supports the automated refinement of specifications to code in several languages. We have been extending Specware to support a coalgebraic style of specification which is suitable for capturing the requirements on stateful, non-terminating, and concurrent software systems. The focus of this talk is on mechanized transformations that refine a coalgebraic specification by incrementally adding implementation detail. One such transformation is called observer maintenance and implements a form of code incrementalization. Other examples include transformations to simplify code expressions, and to refine high-level datatypes to low-level types. The resulting refinement process aims to generate both code and its proof of correctness without the need for post-hoc verification. Applications under current development include high-performance constraint solvers, concurrent garbage collection, and network protocol software. (Received September 26, 2012)

1086-68-2981 **Barna L Bihari*** (bihari@llnl.gov), Lawrence Livermore National Laboratory, L-557, 7000 East Avenue, Livermore, CA 94550. *Computing on Sequoia: The Search for Synergy Between Algorithms and Hardware*.

Having co-designed and successfully installed Sequoia, the fastest supercomputer in the world comes with its own set of challenges and responsibilities for Lawrence Livermore National Laboratory. The efficient use of a 1.6

million core massively parallel system requires not just a fast and novel hardware design, but also modifications to, and occasionally replacement of, the existing mathematical algorithms. There is an increasing amount of empirical evidence that not just the code developer, but the applied mathematician as well as the numerical analyst needs to be aware of the computer hardware which is becoming increasingly innovative, complex, and heterogeneous. To this end, we will introduce and present some experiments with transactional memory (TM) which, for the first time, is implemented in hardware on IBM's Blue Gene/Q architecture. We will discuss the algorithmic as well as the performance implications of TM, concluding with computational results. (Received September 26, 2012)

1086-68-2985 **Iraj Kalantari** (i-kalantari@wiu.edu), Department of Mathematics, Western Illinois University, Macomb, IL 61455, and **Mojtaba Moniri*** (m-moniri@wiu.edu), Department of Mathematics, Western Illinois University, Macomb, IL 61455. *Euler's Machin-like Formula Iterated, Maximal Dilation and Switch to Remainder*. Preliminary report.

This is joint work with Iraj Kalantari. For the number $\arctan(1/2)/\pi$, there is a binary expansion algorithm by Plouffe and Borwein/Girgensohn from the 1990's. This number has been shown to be transcendental by Smith and Margolius in 2003 (and its mere irrationality is a consequence of a result by Jahnke in 2010), although suspected not automatic. The present authors have recently presented an algorithm for the spectrum of the same number, essentially counting some sign changes in solutions to a system of difference equations. Here we consider successive alternating approximations for the same number of the form $1/4 - \arctan(1/3)/\pi$, $1/8 + (1/2)\arctan(1/7)/\pi$, $3/20 - (1/10)\arctan(237/3116)/\pi, \dots$, that we describe, and explore connections with continued fractions and complexity. (Received September 26, 2012)

70 ► *Mechanics of particles and systems*

1086-70-235 **Martha Alvarez*** (mar@xanum.uam.mx), San Rafael Atlixco 186 Col. Vicentina, Iztapalapa, 09340 Mexico, DF, Mexico, **Joaquin Delgado** (jdf@xanum.uam.mx), San Rafael Atlixco 186 Col. Vicentina, Iztapalapa, 09340 Mexico, DF, Mexico, and **Claudio Vidal** (clvidal@ubiobio.cl), Casilla 5-C. Concepcion, VIII-Region, Concepcion, Chile. *Global regularization in the planar equilateral restricted four-body problem*.

We consider the planar equilateral restricted four-body problem, and in particular some its aspects related to regularization and periodic collision orbits. The regularization of binary collisions by a generalization of Birkhoff coordinates is described. The theory is illustrated with the description of a new family of symmetric periodic collision solution. (Received August 10, 2012)

1086-70-367 **Richard Montgomery*** (rmont@ucsc.edu), Mathematics, UC Santa Cruz, Santa Cruz, CA 95064. *Global Regularization and Reduction for Newtonian N body problems*.

If all bodies are treated equally then regularizing and reducing commute. What is the regularized, reduced phase space? Does it help us in understanding the dynamics? We provide partial answers to some low-dimensional cases, including a complete answer to the 1st question for the planar 3-body problem. At the heart of the matter are certain naturally arising projective varieties depending on N and d , the dimension in which the bodies move. This is joint work with Rick Moeckel. (Received August 26, 2012)

1086-70-590 **Samuel R. Kaplan*** (skaplan@unca.edu), One University Heights, CPO#2350, Asheville, NC 28804. *Solar System Formation and Co-orbital Dynamics*. Preliminary report.

The standard model for solar system formation suggests planetary orbits should be nearly circular. However, growing data about exoplanets suggests a wider distribution of eccentricity than is accounted for in the standard model. In this talk we explore the possibility that co-orbital dynamics plays a role in final planetary eccentricity. Note that we say two bodies orbiting a central mass at nearly the same radius are co-orbital. (Received September 07, 2012)

1086-70-678 **Ivana Kovacic*** (ivanakov@uns.ac.rs), Faculty of Technical Sciences, Trg D. Obradovica 6, University of Novi Sad, 21215 Novi Sad, Vojvodina, Serbia. *Truly Nonlinear Oscillators: from their Mathematical Models, the Methods for their Quantitative Investigations to the Phenomena Associated with their Behaviour*.

This lecture is concerned with truly nonlinear oscillators: their restoring force is an odd, single-term powered-form function whose power can be any non-negative real number. First, several mathematical models of this type of force are discussed and their characteristics with respect to a linear restoring force and a multi-term powered-form restoring force that contains a linear term are emphasized. Then, the lecture focuses on free truly

nonlinear conservative oscillators. Exact solutions for their motion expressed in terms of Lyapunov's function and Rosenberg's Ateb functions are considered. In addition, the approach for obtaining very accurate approximate solution for their motion by means of elliptic functions, which has recently been developed by the author and her colleague, is presented. The extensions of this approach to autonomous and non-autonomous non-conservative oscillators are also explained. Some alternative techniques developed by the author that use trigonometric functions but enable one to study both weakly and strongly truly non-linear oscillators are presented as well. Finally, the phenomena arising in truly nonlinear oscillators are addressed and their differences with respect to linear oscillators and other types of nonlinear oscillators are pointed out. (Received September 11, 2012)

1086-70-709 **Richard Moeckel*** (rick@math.umn.edu). *Complex Blow-up of Triple Collision.*

McGehee's blow-up of triple collision is an important tool for analyzing collision and near-collision solutions in the planar three-body problem. The triple collision point in the four-dimensional configuration space is blown up to a three-sphere which acts as a boundary manifold. On the other hand, in complex geometry a different blow-up method is used in which a point in a complex two-dimensional (real four-dimensional) space is blown up to a two-sphere which appears as a codimension-two submanifold in the blown-up space. I will describe how to use this complex blow-up as an alternative to McGehee's method and discuss the relationship between the two approaches. Motivation comes from an ongoing project to blow-up all triple collisions in the four-body problem. (Joint work with Richard Montgomery). (Received September 11, 2012)

1086-70-746 **Xiang Yu***, xiang.zhiy@gmail.com, and **Shiqing Zhang**. *The central configuration formed by two twisted regular polygons.* Preliminary report.

We study the necessary conditions and sufficient conditions for the central configuration formed by two twisted regular polygons, in particular, we prove that two twisted regular polygons must have equal edge number and for the $2N$ -body problem, the twisted angles must be $\theta = 0$ or $\theta = \pi/N$, then we also prove that there exists only two simple central configurations for spatial configuration. (Received September 11, 2012)

1086-70-766 **Donald G. Saari*** (dsaari@uci.edu), SSPB, University of California, Irvine, CA 92697-5100. *Mathematics and the mystery of "dark matter".* Preliminary report.

A fascinating issues in astronomy is that mysterious "dark matter" where, for reasons explained in the talk, huge amounts of matter (beyond what has been observed) must exist. But by using standard mathematical arguments from celestial mechanics, new assertions, which raise serious doubts about the "amount of missing mass" are raised. (Received September 12, 2012)

1086-70-786 **Corey Shanbrom*** (cshanbro@ucsc.edu), Department of Mathematics, UC Santa Cruz, 1156 High St, Santa Cruz, CA 95064. *The Kepler Problem on the Heisenberg Group.* Preliminary report.

The Kepler problem is among the oldest and most fundamental problems in mechanics. It has been studied in curved geometries, such as the sphere and hyperbolic plane. Here, we formulate the problem on the Heisenberg group, the simplest sub-Riemannian manifold. Key to this formulation is a 1973 result of Folland, who found the fundamental solution to the Heisenberg sub-Laplacian. We will discuss the geometry of this space and present partial results and first steps towards a solution to the Kepler-Heisenberg problem. This is joint work with Richard Montgomery. (Received September 12, 2012)

1086-70-861 **Baldvin Einarsson*** (baldvine@math.ucsb.edu), Center for Complex and Nonlinear Science, University of California, Santa Barbara, South Hall, Office 6523, Santa Barbara, CA 93106, and **Bjorn Birnir** and **Luis L. Bonilla**. *Synchronization of Schools of Fish.*

We describe an ODE for schools of fish and study the long term behavior of its solutions. The model can be reduced to one ODE for the speed of the individual particle and one for its directional heading. These equations contain the mean speed, \bar{v} , and a Kuramoto order parameter for the phases of the fish velocities, r . We show that the system of equations has two stationary solutions, consisting of an incoherent unstable solution with $r = \bar{v} = 0$ and a globally stable solution with $r = 1$ and a constant $\bar{v} > 0$. We describe these solutions and discuss their stability.

Then, we perturb the directional headings of the particles in two distinct ways, and accelerate the speeds in order to obtain non-stationary, complex solutions. We show that the system exhibits a similar bifurcation to that in Vicsek *et al.* (1995), between phases of synchronization and disorder (Received September 14, 2012)

- 1086-70-1250 **Lennard F. Bakker*** (bakker@math.byu.edu), 366 TMCB, Provo, UT 84602, and **Skyler C. Simmons** (xinkaisen@gmail.com). *The Rhomboidal Symmetric-Mass Four-Body Problem.*

We consider the existence and stability of periodic solutions with regularizable collisions in the rhomboidal symmetric-mass four-body problem. In the two degrees of freedom setting, where the analytic existence of the periodic solutions is given by a variational method, we show that the periodic solutions are numerically linearly stable for most of the values of the mass parameter. In the four degrees of freedom setting, we establish the analytic existence of the periodic solutions and numerically investigate their linear stability. (Received September 20, 2012)

- 1086-70-1447 **John B Little*** (little@mathcs.holycross.edu), Department of Mathematics and Computer Scienc, College of the Holy Cross, Worcester, MA 01610. *Continua of central configurations with a negative mass in the n -body problem.*

A configuration of bodies in the Newtonian n -body problem is said to be a central configuration if the acceleration vector of each body is directed toward the center of mass of the configuration and the proportionality factors between the accelerations and the displacements from the center of mass are all equal. Two central configurations are equivalent if some composition of a rigid motion and scaling maps one to the other. One of the main open questions about central configurations is: Given a set of (positive) masses, is the set of equivalence classes of central configurations finite, or can there be a positive-dimensional family for some collection of masses? For $n = 3$ and 4, it is known that the set of equivalence classes is finite for all collections of positive masses. However, Gareth Roberts produced a 5-body example in the plane, containing one negative mass, where the set of equivalence classes of central configurations is a curve ("a continuum"). In this talk, we will present a construction that generalizes Roberts' example to produce similar continua of central configurations with one negative mass in all even dimensions greater than or equal to 4. The construction relies mainly on properties of regular polyhedra and their symmetry groups. (Received September 22, 2012)

- 1086-70-1545 **Marshall Hampton*** (mhampton@d.umn.edu), 1117 University Dr., Duluth, MN 55812. *Generalized Albouy-Chenciner equations for central configurations: a test case for methods from tropical geometry and fewnomial theory.*

In 1998 Alain Albouy and Alain Chenciner provided an elegant new formulation of polynomial equations for central configurations of the N -body problem. Central configurations, which include relative equilibria configurations, provide major landmarks in the study of the N -body problem. With a change of an exponent in the potential function, the Albouy-Chenciner equations can also be applied to the study of N point vortices. A famous problem in celestial mechanics is to determine the finiteness of the relative equilibria for a fixed set of positive masses; the Albouy-Chenciner equations provide a polynomial system that have been used to partially answer that problem. We will review some of these developments and then consider the additional issue of how many of the solutions are real for a family of potential functions that includes the Newtonian and point vortex cases. It is perhaps surprising that the number of positive real solutions to this family may not depend on the potential's exponent at all, although results from BKK theory (Bernstein, Kushnirenko, and Khovanskii) provide some explanation. (Received September 23, 2012)

- 1086-70-2108 **Elizabeth A Zollinger*** (ezollinger@sjcny.edu), 245 Clinton AVE, St. Joseph's College, Brooklyn, NY 11205. *Averaging theory for finding analytically periodic orbits for the 3-body problem.*

Building on the work by Jaume Llibre for finding analytically periodic orbits of differential equations in the Lorenz model and those in Chua's class, we apply the averaging theory to the Newtonian n -body problem. Starting with the family of equal mass 3 bodies (which can be pictured nicely on the shape sphere) we compute eigenvalues to verify that periodic orbits must exist. Connections are then made to the geometric problem with the the 3 bodies starting at collinear and ending, at $t = 1$, in an isosceles triangle. (Received September 24, 2012)

74 ► *Mechanics of deformable solids*

- 1086-74-314 **Anna Zemlyanova*** (azem@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843. *A surface-tension-based approach to the elimination of crack-tip singularities in fracture mechanics.*

A new model of fracture mechanics incorporating a curvature-dependent surface tension acting on the boundaries of a crack is considered. The model is studied on the example of a single curvilinear crack in an infinite thin

plate. Linear elasticity is assumed for the behavior of the material of the plate in a bulk. A non-linear boundary condition with a consideration for a surface tension dependent on the curvature of the crack is given on the crack boundary. Using the methods of complex analysis, such as Muskhelishvili complex potentials and Savruk's integral representations, the problem is reduced to a system of two singular integro-differential equations. This system is further reduced to a system of two Fredholm equations. It is proved that the introduction of the curvature-dependent surface tension eliminates classical power singularities of the order $1/2$ at the tips of the crack. Numerical computations are presented. (Received August 20, 2012)

1086-74-1084 **Hyunsun Lee*** (hlee@hpu.edu). *Research on estimating the overall behavior of heterogeneous composites based on Hashin-Shtrikman variational principle and its applications.*

To find the overall mechanical properties of heterogeneous particulate composites like rocket propellant, granular media, the well-known Hashin-Shtrikman-Willis variational principle is used. This theoretical framework is directly applied to numerically generated or real materials. The emphases are placed on anisotropic material responses of the tomographically characterized packs with different order of statistics used in the mathematical models and on an highly efficient numerical integration of highly complex functions such as the high-order probability functions and the second derivative of Green's function in the calculation. Selected examples are presented to illustrate both the numerical and physical facets of the work. A few interesting future applications associated with Liquid Crystal Elastomers (LCE) are presented. (Received September 18, 2012)

1086-74-1111 **Matthias Augustin*** (augustin@mathematik.uni-kl.de), P. O. Box 30 49, 67653 Kaiserslautern, Germany. *Stress field simulations in geothermal reservoirs.* Preliminary report.

With the rising demand for energy and the accompanying short running of resources, expanding the use of renewables is inevitable. A very promising source of energy is the heat stored in the earth's crust which is used by so-called geothermal facilities. Scientists from fields like geology, geo-engineering, geophysics and especially geomathematics are challenged to help making geothermics a reliable and safe energy production method. One of this challenges is modeling the mechanical stresses within a reservoir.

This talk will give an insight into stress field simulations. After introducing the basic equations and their relations to more familiar ones (heat equation, Stokes equations, Cauchy-Navier equation), we discuss the so-called method of fundamental solutions and how it can be used in our task. Based on the properties of the fundamental solutions, theoretical results will be established. The talk concludes with some numerical examples to inspire further investigations in the performance of the method and an outlook on further research goals. (Received September 19, 2012)

1086-74-1373 **Rich Lehoucq*** (rblehou@sandia.gov), Po box 5800, Albuquerque, NM 87185. *The Peridynamic Nonlocal Continuum Theory.*

My talk introduces the nonlocal balances of momentum and energy. The nonlocal force and energy densities are given by integral operators that are the nonlocal analogues for the classical force and energy densities. The integral operators sum forces and power expenditures among volumes separated by a finite distance and so represent nonlocal interaction. This is in contrast to the classical densities in which interaction only occurs between volumes in direct contact—the interaction is therefore deemed local. The integral operators obviate special treatment at points of discontinuity conventionally employed because spatial derivatives are avoided. The resulting balance laws extend the classical theory of continuum mechanics to allow for discontinuities. (Received September 21, 2012)

1086-74-2074 **Qichuan Bai***, bai@math.psu.edu, and **Andrew Belmonte** and **Qiang Du**. *Dynamic buckling of elastic materials.* Preliminary report.

We consider the buckling phenomenon of an elastic beam with one end subject to a sudden impact while the other end fixed. We adopt a coupled PDE system in terms of normal (lateral) displacement u and tangential displacement v , which is one hyperbolic equation and an elliptic type problem in some parameter region. We test broad range of parameters in the numerical simulations. We have identified some interesting buckling patterns which have been observed in the lab such as reflective buckling. This is a joint work with Andrew Belmonte and Qiang Du. (Received September 24, 2012)

- 1086-74-2095 **Bacim Alali**, Department of Scientific Computing, Tallahassee, FL , and **Robert Lipton***, Louisiana State University, Department of Mathematics, Baton Rouge, LA 70803. *Multiscale Analysis of Heterogeneous Media in the Peridynamic Formulation.*

A methodology is presented for investigating the dynamics of heterogeneous media using the nonlocal continuum model given by the peridynamic formulation. The approach presented here provides the ability to model the macroscopic dynamics while at the same time resolving the dynamics at the length scales of the microstructure. Central to the methodology is a novel two-scale evolution equation. The rescaled solution of this equation is shown to provide a strong approximation to the actual deformation inside the peridynamic material. The two scale evolution can be split into a microscopic component tracking the dynamics at the length scale of the heterogeneities and a macroscopic component tracking the volume averaged (homogenized) dynamics. The interplay between the microscopic and macroscopic dynamics is given by a coupled system of evolution equations. The equations show that the forces generated by the homogenized deformation inside the medium are related to the homogenized deformation through a history dependent constitutive relation. (Received September 24, 2012)

- 1086-74-2160 **Brianna Kathleen Lynn*** (brianna.lynn2@gmail.com), 8124 Greeley Blvd., Springfield, VA 22152, and **Mauro Wilfredo Rubio** (mrubio4@masonlive.gmu.edu), 2703 Radford St., Alexandria, VA 22302. *Static Two-Dimensional Sponge Deformation.*

The shape of elastic physical objects can be modeled by partial differential equations. We describe an approach to determine the elasticity parameter of a sponge under compression from experimental measurements. After solving the partial differential equations, we used a nonlinear optimization technique to determine the elastic parameter. (Received September 24, 2012)

76 ► *Fluid mechanics*

- 1086-76-120 **Joel E. Hedman*** (hedm5372@stthomas.edu), University of St. Thomas, Mail 1402, 2115 Summit Ave, St. Paul, MN 55105, and **Toby Hillman** (hill13408@stthomas.edu), University of St. Thomas, Mail 6658, 2115 Summit Ave., St. Paul, MN 55105. *Modeling Turbulence with Delay Equations.* Preliminary report.

Understanding flow patterns in atmospheric boundary layer is important for study and prediction of thunderstorm behavior that includes tornado formation. Specifically, turbulent properties of rotating air can determine scale and other characteristics of the flow near the ground. In this work, we apply delay equations that capture coherence patterns of the atmospheric flow near the boundary in Boussinesq approximation of the governing equations. We examine numerical delay in space and time. First we address one space dimension using the Burgers equation. We analyze both viscous and inviscid cases, with the eventual goal of applying this to the full three-dimensional case as well. (Received July 25, 2012)

- 1086-76-215 **Song Chen*** (chensong250@gmail.com), **Yanzhao Cao** and **A.J. Meir**. *On the equations of quasistatic poroelasticity with dilatation dependent hydraulic conductivity: existence, uniqueness, and finite element approximation.*

The equation of quasi-static poroelasticity modeling a flow through elastic porous media is considered. It is assumed that the hydraulic conductivity depends nonlinearly on the displacement of the medium. Well posedness is proved using the modified Rothe's method. Numerical approximation of solutions based on the finite element method are constructed. Error estimates are obtained and numerical experiments are conducted to demonstrate the theoretical results and the efficiency and accuracy of the numerical method. (Received August 07, 2012)

- 1086-76-241 **George H Lytle*** (george.lytle@asbury.edu), 1 Macklem Drive, Wilmore, KY 40390. *Do the Wave: Applying Group Finite Elements to the Shallow Water Equations.* Preliminary report.

We consider the general nonlinear Shallow Water Equations. After a discussion of the Method of Characteristics solution, we propose a numerical code using Group Finite Elements. Our simulation exhibits several aspects of the analytical solution, but it is limited by the constraints on the boundary at $x = \ell$. This project was conducted at George Mason University during the 2012 Research Experience for Undergraduates program funded by the National Science Foundation. (Received August 11, 2012)

- 1086-76-820 **Katie L Oliveras*** (oliverak@seattleu.edu), **Vishal Vasan**, **Bernard Deconinck** and **Diane Henderson**. *Recovering the Water-wave Surface from Pressure Measurements.*

A new method is proposed to recover the water-wave surface elevation from pressure data obtained at the bottom of the fluid. The new method requires the numerical solution of a nonlocal nonlinear equation relating the pressure and the surface elevation which is obtained from the Euler formulation of the water-wave problem without approximation. From this new equation, a variety of different asymptotic formulas are derived. The nonlocal equation and the asymptotic formulas are compared with numerical data, physical experiments, and field data. (Received September 13, 2012)

- 1086-76-837 **Yuriko Renardy*** (renardy@vt.edu), Department of Mathematics, 460 McBryde Hall, Virginia Tech, Blacksburg, VA 24061-0123, and **Kara L Maki** (kmaki@rit.edu), School of Mathematical Sciences, Rochester Institute of Technology, Rochester, NY 14623. *A mathematical perspective on ketchup.*

This is joint work with K. Maki (Rochester Institute of Technology). We present a mathematical perspective to study the dynamics of constitutive models with non-monotonic curves that naturally explains some of the main features of making ketchup flow in shear. The application of some non-zero shear stress is necessary before the material begins to flow or yield. If the applied stress is decreased, then there is some non-zero critical value beyond which the material apparently stops flowing (unyields). The yield stress and unyielding stress depend on the amount of time since the material was last stressed. As an illustration, we use a viscoelastic constitutive model for homogeneous parallel shear flow, and study the dynamics initiated by a step-up or step-down in prescribed shear stress. The model is a modified 'partially extending strand convection' (Larson 1984) model with a Newtonian solvent contribution. We address the case where the relaxation time is large. This introduces a small parameter, so that perturbation analysis with multiple time scales are used in conjunction with numerical simulation of the governing equations. In conclusion, we relate some predictions of the model to published experimental data. (Received September 13, 2012)

- 1086-76-1046 **Peter Zhevandrov*** (pzhevand@umich.mx), Fac. de Ciencias Físico-Matemáticas, Universidad Michoacana, Ciudad Universitaria, 58030 Morelia, Mich., Mexico, and **María Isabel Romero Rodríguez** (mariarr@unisabana.edu.co), Facultad de Ingeniería, Universidad de La Sabana, Campus Universitario "Puente del Común", Chía, Cund., Colombia. *Scattering and total reflection for oblique waves in a two-layer fluid.*

We study trapped modes and the scattering problem for oblique waves in a two-layer fluid in the shallow water approximation with a weakly perturbed depth, $h = h_0 + \epsilon f(x)$, $\epsilon \ll 1$, where f is continuously differentiable and has compact support. We assume that the perturbation is cylindrical. The linearized system describing oblique waves harmonic in time in this setting has the form of two coupled second order ODEs with the spectral parameter $\lambda = \omega^2$ (ω is the frequency). In the absence of the perturbation, the continuous spectrum is the ray $\lambda \geq \lambda_1 > 0$ with an embedded cut-off $\lambda_2 > \lambda_1$. This spectrum has multiplicity 2 for $\lambda_1 < \lambda < \lambda_2$, and multiplicity 4 for $\lambda > \lambda_2$. Under the perturbation, the cut-offs $\lambda_{1,2}$ can produce eigenvalues. For a "bump" on the bottom, there exists an eigenvalue to the left of λ_1 . Under certain "orthogonality conditions", the other cut-off also produces an eigenvalue. If the "orthogonality conditions" are not satisfied, this eigenvalue becomes a complex pole of the reflection coefficient of the corresponding scattering problem. In this case, the reflection coefficient is almost 1 when λ is equal to the real part of the pole. (Received September 18, 2012)

- 1086-76-1143 **Nicholas E Pizzo*** (npizzo@ucsd.edu) and **W. Kendall Melville**. *Vortex generation by deep water breaking waves.*

The connection between wave dissipation by breaking deep-water surface gravity waves and the resulting turbulence and mixing is crucial for an improved understanding of air-sea interaction processes. In this study, we consider the relationship between a breaking wave and an impulsively forced fluid, allowing us to build upon the classical work on vortex ring phenomena to quantify the circulation generated by a breaking wave. From this we find that the circulation $\Gamma = \chi c^3/g$, where χ is a proportionality factor, c is the phase speed of the wave and g is the acceleration due to gravity. Using a scaling argument, we show that $\chi = \alpha(hk)^{\frac{3}{2}}$, where hk is a breaking slope parameter and α is a constant. This formula then allows us to find a direct relationship between the circulation and the wave energy dissipation rate due to breaking, ϵ . We find agreement between our model and the limited available experimental data. Finally, potential application of this theory to ocean processes will be discussed. (Received September 19, 2012)

1086-76-1546 **Dambaru Bhatta*** (bhattad@utpa.edu), 1201 West University Drive, Department of Mathematics, Edinburg, TX 78539, and **Daniel N Riahi**. *Linear and First Order Solutions for a Three Dimensional Convective Flow in a Mushy layer*. Preliminary report.

Here we present the linear and first order solutions for a three dimensional convective flow in a mushy layer which is observed during solidification of binary alloys. Mushy layer is a partially solidified material sandwiched between a liquid and a solidified material. We consider a three dimensional case where mush-liquid interface is impermeable. After obtaining the basic state solutions, we find the linear and adjoint systems in terms of basic state solutions, non-dimensional parameters such as Rayleigh number, Stefan number and Concentration ratio. Then we derive the first order solutions. Numerical results of the solutions for velocity and solid volume fraction are presented. (Received September 23, 2012)

1086-76-1731 **Catherine Sulem*** (sulem@math.toronto.edu), Department of Mathematics, University of Toronto, 40 St George Street, Toronto, Ontario M5S2E4, Canada. *Coupling between internal and surface waves in a two-layers fluid*.

Internal waves that occur within a fluid stratified by temperature or salinity variation, are commonly generated in the oceans. They appear as large amplitude, long wavelength nonlinear waves and can propagate over large distances.

In some physically realistic situations, the visible signature of internal waves on the surface of the ocean is a band of roughness, sometimes referred to as a ‘rip’ which propagates at the same velocity as the internal wave, followed after its passage, by the ‘mill pond’ effect, the complete calmness of the sea.

We propose an asymptotic analysis of the coupling between the interface and the free surface of a two layers fluid in a scaling regime chosen to capture these observations. In particular, we describe the rip region of the free surface as being generated by the resonant coupling between internal solitons and the free-surface wave mode. We also give an explanation of the mill pond effect as the result of a strong reflection coefficient for free-surface waves in the modulational regime, in a frame of reference moving with the internal soliton.

This is a joint work with Walter Craig and Philippe Guyenne. (Received September 24, 2012)

1086-76-1823 **Mathieu Desbrun***, 1200 E. California Blvd, MS 305-16, Pasadena, CA 91125. *Geometric, Variational Discretization of Continuum Theories*.

This talk will introduce geometric, variational discretizations of continuum theories arising in fluid dynamics, magnetohydrodynamics (MHD), and the dynamics of complex fluids. A central role in these discretizations is played by the geometric formulation of fluid dynamics as geodesics on the group of volume-preserving diffeomorphisms of the fluid domain. Inspired by this framework, we construct a finite-dimensional approximation to the diffeomorphism group and its Lie algebra, thereby permitting a variational temporal discretization of geodesics on the spatially discretized diffeomorphism group. The extension to MHD and complex fluid flow is then made through an appeal to the theory of Euler-Poincare systems with advection. Among the hallmarks of these new numerical methods are exact preservation of momenta arising from symmetries, automatic satisfaction of solenoidal constraints on vector fields, good long-term energy behavior, robustness with respect to the spatial and temporal resolution of the discretization, and applicability to irregular meshes. If time allows, we will also discuss some recent extensions, including spectral computations and high-resolution Lie derivatives. (Work in collaboration with Dmitry Pavlov, Evan Gawlik, Patrick Mullen, and Jerrold E. Marsden.) (Received September 24, 2012)

1086-76-1910 **Gregory R Baker*** (baker@math.osu.edu), Department of Mathematics, The Ohio State University, 231 W. 18th Ave, Columbus, OH 43210, and **Chao Xie** and **Jeong-Sook Im**. *Curvature singularities on the surface of water waves*.

Boundary integral methods are naturally suited for tracking the motion of free surfaces in incompressible, inviscid flows. Particular examples include the propagation of waves on the surface of deep or shallow water. Not only is the method naturally adaptive when fluid particles are tracked by following their motion, but also spectrally accurate numerical methods ensure high enough accuracy that important mathematical behavior can be discerned. A pleasing viewpoint arises when the curvature of the surface location is considered as a complex-valued function of the complex-valued arclength. Pole singularities are found that move around the complex plane as the wave progresses. Of special interest, is whether these singularities reach the real axis, when the curvature singularity becomes physically real. They do not reach the real axis after waves have broken, but come extremely close as the curvature of the falling tip becomes extremely large. On the other hand, there is numerical evidence that corners can form in finite time. (Received September 24, 2012)

1086-76-1953 **Long H Le*** (longl@uca.edu) and **Jonathan Taylor** (jst04004@gmail.com). *A model for submarine granular flow with erosion*. Preliminary report.

Submarine avalanches, while have been understudied, can have devastating effects. Not only can they destroy underwater constructions, they can also initiate tsunami that kills people. In this paper, we present a Savage-Hutter type model for submarine granular flow down an incline. This model includes erosion at the basal surface of the granular flow. Numerical experiments are performed with this model and the results will be discussed. (Received September 24, 2012)

1086-76-2215 **Bruno Gabriel Beltran*** (brunobeltran0@gmail.com), 1173 Lauren Logan Ln, Sulphur, LA 70665, and **Daniel Burkow, Courtney Bruce and Sarah Erickson**. *Secondary Aneurysm Formation Due to the Effects of a Primary Aneurysm*.

Intracranial aneurysms are localized dilations of arterial vessels located around the Circle of Willis, an important network of arteries at the base of the brain. Aneurysms are at constant risk of hemorrhage; however, the number of benign cases carried by the populace, the dangers of treatment, and the risk of recurrence often null the efficacy of preventative surgery. Although the mechanisms behind the formation of individual intracranial aneurysms have been thoroughly modeled as the consequence of local hemodynamic conditions, previous simulations have concentrated on single aneurysms. Using OpenFOAM, an open source fluid dynamics toolkit, we study how changes in the hemodynamics within the Circle of Willis caused by the presence of a primary aneurysm can facilitate the formation of a secondary aneurysm. We measured changes in wall shear stress on the anterior communicating artery given a primary aneurysm at the bifurcation between the posterior communicator artery and the basilar artery. The small decrease we found, of around 0-4%, is exposit as evidence that multiple aneurysms form independently of each other. (Received September 25, 2012)

1086-76-2289 **Xinli Wang***, 800 University Way, Spartanburg, SC 29303, and **German Drazer**. *Transport of Brownian particles in a curved channel confined by a periodic potential*.

This work is motivated by novel separation strategies in microfluidic devices by taking advantage of the unprecedented control on geometry and chemistry of the stationary phase at scales that are comparable to the size of the transported species. Asymptotic analysis is applied to analytically calculate the average velocity in the case of the small ratio between the channel width and the length of one period. The result shows that the normalized average velocity does not depend on the Peclet number and is inversely proportional to the length of the channel length. (Received September 25, 2012)

1086-76-2402 **John D Carter*** (carterj1@seattleu.edu), Seattle University, 901 12th Ave, Seattle, WA 98122, and **Harvey Segur and David George**. *Dispersion in shallow water*.

In a series of physical experiments of surface water waves, dispersion appears to play a very important role in the evolution of waves of depression. This suggests that the (nondispersive) shallow-water equations miss some important features of the wave evolution. In this talk we compare measurements from a series of shallow-water experiments with numerical simulations of the classic shallow-water, Korteweg-deVries, and other dispersive equations. (Received September 25, 2012)

1086-76-2448 **Antonio Mastroberardino*** (axm62@psu.edu), 4205 College Drive, Erie, PA 16563. *On the limitations of Kummer's function in heat transfer problems*.

The study of two-dimensional boundary layer flow over a moving surface in a fluid at rest was initiated by Sakiadis. Crane extended the work of Sakiadis by obtaining an exact analytical solution for the case of a linearly stretching surface. In regard to several recent studies that incorporate a viscoelastic fluid and heat transfer analysis, I will demonstrate that the reported solutions of the thermal energy equation given in terms of Kummer's function do not converge at the boundary, and therefore, the values of the wall temperature gradient and wall temperature for the two general types of non-isothermal boundary conditions are incorrect. In contrast I will show that the homotopy analysis method (HAM) provides accurate values of the relevant boundary derivatives via a graphical and numerical demonstration of convergence. (Received September 25, 2012)

1086-76-2472 **Y. Tony Song*** (song@jpl.nasa.gov), 4800 Oak Grove Drive, Pasadena, CA 91109. *tsunami modeling and satellite observations for early warnings*. Preliminary report.

This study discusses how tsunamis form from earthquakes and how remote-sensing technologies can be used to detect tsunami scales. According to the conventional theory, tsunamis are formed by the vertical deformation of the seafloor during undersea earthquakes. However, our recent studies contradict to the established theory. We will first show evidence—based on GPS displacement measurements, satellite-inferred gravity changes (fault movements), radar altimeter data, and seismic inversions—that the momentum transferred by the horizontal motions of continental slopes is the major force of tsunamis. The tsunami propagation patterns, in three

historical cases, are shown to be controlled by the horizontal slope motions with asymmetric features with both leading elevation waves and depression waves, best explained by the horizontally-forced mechanism. We will then demonstrate how remote sensing in conjunction with the new theory can be used effectively to detect tsunami genesis and its energy scales for early warnings. (Received September 25, 2012)

1086-76-2500 **Michael Renardy*** (mrenardy@math.vt.edu) and **Xiaojun Wang**. *Well-posedness of boundary layers in viscoelastic flows*.

The Prandtl equation can formally be derived to describe the boundary layer in a high Reynolds number flow. However, establishing the mathematical well-posedness of this equation has been found to be far from easy. In this lecture, I shall present recent result on the well-posedness of boundary layer equations for viscoelastic flows. These equations are in many respects better behaved than their Newtonian counterparts. (Received September 25, 2012)

1086-76-2580 **Christopher K.R.T. Jones*** (ckrtj@email.unc.edu), Department of Mathematics, Phillips Hall, University of North Carolina, Chapel Hill, NC 27599-3250. *Lagrangian Data Assimilation as a Paradigm in Climate*. Preliminary report.

Assimilating Lagrangian data into ocean models has proved very successful. Its importance derives from the fact that most subsurface observations are made by instruments that are carried by the flow itself. Its mathematical structure, however, is very suggestive for climate problems generally. It separates the system state in various ways: fast/slow; high/low-dimensional; relatively tame/chaotic; linearizable/highly nonlinear. Its success will be outlined and explained as well as the possibility of its being a paradigm discussed. (Received September 25, 2012)

1086-76-2623 **Sanja V Pantić*** (pantic@math.uic.edu), MSCS Department, 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60607-7045, and **Jerry L Bona**. *Global well-posedness for the eBBM-model*.

The BBM-equation, was first studied as a model for small-amplitude long waves that propagate on the free surface of a perfect fluid. As an alternative to the KdV-equation, it features a balance between nonlinear and frequency-dispersive term that allow existence of traveling waves that are smooth and symmetric about their peak. Such waves, that decay rapidly to zero on their outskirts are known as solitary waves. Our interest is in such solitary-wave solutions of one of the natural generalizations of the BBM-equation, the Extended BBM (eBBM)-equation

$$u_t + u_x + \beta_p(u^p)_x + \beta_q(u^q)_x - u_{xxt} = .,$$

These equations feature a balance between three terms two nonlinear terms $(u^p)_x$ and $(u^q)_x$ and the dispersive term $-u_{xxt}$. Our interest is particularly in powers p and q for which $p < 5 < q$.

We show that the initial-value problem for the eBBM-equation is globally well-posed on the real line and in the periodic setting. This gives a rigorous foundation from which to study the stability theory of its solitary-wave solutions. We then present some numerical simulations concerning the deportment of solitary waves under perturbations. Applications of the discovery of the two separate stable regimes that the eBBM-model features will be discussed. (Received September 25, 2012)

1086-76-2751 **Pavel Belik*** (belik@augsborg.edu), 2211 Riverside Ave, CB 93, Minneapolis, MN 55454, and **Douglas P. Dokken**, **Mikhail M. Shvartsman** and **Kurt Scholz**. *Alternative powers of decay in swirling vortex solutions*. Preliminary report.

We consider a modification of the fluid flow model for a swirling vortex developed by J. Serrin, where velocity decreases as the reciprocal of the distance from the vortex axis. Recent studies, based on radar data of selected severe weather events, indicate that the angular momentum in a tornado may not be constant with the radius, and thus suggest a different scaling of the velocity/radial distance dependence. Motivated by this suggestion, we consider Serrin's approach with the assumption that the velocity decreases as the reciprocal of the distance from the vortex axis to the power b with a general $b > 0$. This leads to a boundary-value problem for a system of nonlinear ordinary differential equations. We analyze this problem for particular cases, both with nonzero and zero viscosity, discuss the question of existence of solutions, and use numerical techniques to describe those solutions that we cannot obtain analytically. (Received September 25, 2012)

1086-76-2918 **Stuart Kent*** (skent@math.arizona.edu) and **Shankar Venkataramani**. *Singularities in Free interface problems and Universality*.

We explore an analogy between microelectromechanical systems (MEMS), in which an elastic conducting plate is deflected by an applied potential, and selective withdrawal systems, in which a fluid interface is deflected by

a viscous flow. These systems show a rich bifurcation structure, and potential singularities in the equilibrium interfaces as the forcing strength is increased. Both systems are typified by a feedback between sharp geometry of the interface and high stresses (electrostatic in the first case; viscous in the latter).

This feedback presents a challenge to the analysis of this problem. We describe an asymptotic matching technique for conformal maps which we apply to solve the strong deflection regime for the electrostatic problem. We also discuss the extension of these methods to the fluid flow problem, and the universality classes/types of singularities for free interface problems. (Received September 26, 2012)

78 ► *Optics, electromagnetic theory*

1086-78-2469 **Kyle Shaw*** (kshaw11@masonlive.gmu.edu), 254 Briarwood Drive, Elverson, PA 19520, and **Dan Weingarten** (dweingar@gmu.edu), 5932 Bangor Drive, Alexandria, VA 22303. *Optimizing Surface Plasmon Generation.*

Surface Plasmon Resonance (SPR) is a collective oscillation of traveling charge density waves present at the interface of two media (metal-dielectric). Our project focuses on developing an optimization algorithm for finding geometric parameters of the grating nanodevice that provide the most efficient conversion of energy between the Gaussian beam and the SPR modes. The optimization algorithm is based on iterative solving of Maxwell's equations by the finite element method. The developed technique will allow control of the electromagnetic field below the wavelength. This results in applications ranging from computer chip enhancements to more powerful lenses all the way to the extreme case of cloaking at the nano level. (Received September 25, 2012)

80 ► *Classical thermodynamics, heat transfer*

1086-80-887 **Perry Y.C. Lee*** (plee@kutztown.edu), Lytle Hall 267, Department of Mathematics, Kutztown University of Pennsylvania, Kutztown, PA 19530, and **Wey Herng Leong** (weyleong@ryerson.ca), Department of Mechanical, and Industrial Engineering, Ryerson University, Toronto, Ontario M5B 2K3, Canada. *Design Parameter Settings for a Physically-Realizable Uniform Temperature Boundary Condition Specification on a Wall of a Cubicle Enclosure.*

Design parameters for an internal natural convection heat transfer cubical apparatus are presented. These parameters provide the necessary settings so that a uniform temperature profile on a wall of this apparatus can be physically achieved. Based on the initial design of the apparatus, measurements showed that a temperature non-uniformity existed along this wall in the excess of 4% error. This error was high enough that the benchmark study could not be carried out as a temperature non-uniformity of less than 1% was desired.

The original design was modified by adding two auxiliary heaters near the wall where the uniform temperature profile was desired. Before the implementation of these heaters onto the apparatus, a detailed mathematical analysis was conducted to determine the position and the width of the heaters, and to establish the heat flux supplied by these heaters to reduce the temperature non-uniformity to less than 1%.

A generalized set of design parameters that can physically achieve the uniform temperature setting along the wall to within 1% error is presented. With these parameters, this would enable any designer with the flexibility in choosing which parameters can be used based on their need. (Received September 14, 2012)

81 ► *Quantum theory*

1086-81-87 **Wataru Ichinose*** (ichinose@math.shinshu-u.ac.jp), Asahi 3-1-1, Matsumoto, Nagano. *On the Feynman path integral with spin for non-relativistic quantum electrodynamics.*

The Feynman path integral for non-relativistic QED with spin can be defined rigorously via the non-perturbative method as in Feynman and Hibbs's book in 1965. We begin with the Lagrangian function representing the motion of classical charged particles and the Maxwell equations. We suppose that the quantum particles have spin. Then, the Feynman path integral with spin can be constructed in terms of piecewise straight lines, i.e. the motion of free particles and photons. It is also proved that the Feynman path integral satisfies the equation derived from operational method. We note there that the Coulomb potential appears between charged particles.

References.(1) On the Feynman path integral for nonrelativistic quantum electrodynamics, Rev. Math. Phys. 2010. (2) A mathematical theory of the Feynman path integral for the generalized Pauli equations, J.

Math. Soc. Japan, 2007. (3) On the semi-classical approximation of the solution of the Heisenberg equation with spin, Ann. Inst. Henri Poincaré, Phys. Théor. 1997. (Received July 11, 2012)

1086-81-475 **Clark Musselman*** (clark@simons-rock.edu), 84 Alford Rd, Great Barrington, MA 01230, and **Jeffrey Schenker** (jeffrey@math.msu.edu). *Diffusion for Markov Wave Equations.*

We consider the long time evolution of solutions to a Schrödinger-type wave equation on a lattice, with a divergence-form, Markov, random generator. We show that solutions to this problem diffuse. That is, the amplitude converges to the solution of a diffusion equation, in the diffusive scaling limit.

Additionally, we expand upon a similar result due to Kang and Schenker for a Markov-Schrödinger wave equation by computing higher moments of position, also in the diffusive scaling limit. (Received September 04, 2012)

1086-81-520 **Katherine A. Kime*** (kimek@unk.edu), Dept. of Mathematics and Statistics, Founders Hall, University of Nebraska Kearney, Kearney, NE 68849. *Explicit Quantum Controls.*

We compute explicit quantum controls which transfer initial states with certain properties to terminal states with different properties. Increasing the number of intermediate states introduces flexibility but also computational complexity. Discretized stationary states of the Schrodinger equation are inherent in the numerical approximations we use, and we describe their connection to Feynman-Hibbs path integrals. (Received September 05, 2012)

1086-81-679 **Takuya Machida*** (bunchin@meiji.ac.jp), Meiji University, 1-1-1 Higashi Mita, Tama, Kawasaki, Kanagawa 214-8571, Japan. *Limit distributions of quantum walks and 2nd order linear ordinary differential equations.*

Quantum walks are considered as quantum versions of classical random walks. The limit theorems of discrete- and continuous-time quantum walks on the line have been intensively investigated. Particularly, the limit distributions play an important role in letting us know the spatial distribution of the walkers after many steps. In this presentation, we focus on the standard quantum walks on the line and introduce relationships between their limit distributions and 2nd order linear ordinary differential equations. In addition, by using our results, we discuss connection between discrete- and continuous-time quantum walks. My talk is based on the work with Norio Konno and Tohru Wakasa. (Received September 11, 2012)

1086-81-807 **Yutaka Shikano*** (yshikano@ims.ac.jp), 38 Nishigo-Naka, Myodaiji, Okazaki, Aichi 444-8585, Japan. *On Inhomogeneous Quantum Walk.*

We have recently developed the discrete time quantum walk with the spatial different coins. In the spatially random coin case, the Anderson localization like behavior can be observed. In the spatially aperiodic coin case, the different type localization can be observed. To obtain the relationship between the localization and the delocalization, we have studied the eigenvalues of the one-step quantum walk operator. In the spatially aperiodic coin case, the Hofstadter butterfly is shown and gives an evidence of the multifractal system. (Received September 13, 2012)

1086-81-823 **Maurice J LeBlanc*** (mleblanc@math.uga.edu), Department of Mathematics, University of Georgia, Boyd Graduate Research Center, Athens, GA 30602. *Building a Free Quantum Field Theory on a Curved Spacetime.* Preliminary report.

We will first present a stream-lined version of the Wightman Axioms for a free quantum field theory for particles of mass m and spin zero in a flat space-time. We will then report on our progress toward constructing quantum field theories which satisfy appropriately modified axioms on a curved space-time using Wigner contraction as well as perturbation from the case on flat space-time. (Received September 13, 2012)

1086-81-895 **Tepper L Gill*** (tgill@howard.edu), 2300 6th St. NW, Washington, DC 20059. *The Correct Hilbert Space for Feynman's Formulation of Quantum Theory.*

In this talk, I introduce a new separable Hilbert space, which contains the standard one as a compact dense subspace. This space makes it possible to construct path integrals using Feynman's originally definition and is the correct space for Feynman's formulation of quantum mechanics. The space of finitely additive measures (including the delta function) is contained in the new space and it provides a finite norm for non-absolutely integrable functions. I show that both the convolution and Fourier transform extend to this space as bounded linear operators. This result means that both the Schrödinger and Heisenberg formulations of quantum mechanics may also be formulated on this space. It is well known that the Feynman formulation does not make sense as a theory on the standard one. (Received September 15, 2012)

1086-81-1028 **Sonia Mazzucchi*** (mazzucch@science.unitn.it), via Sommarive 14, I 38123 Trento, Italy. *Feynman path integrals as infinite dimensional oscillatory integrals.*

The talk will describe the theory and some recent applications to nonrelativistic quantum mechanics of "infinite dimensional oscillatory integrals": a particular class of functional integrals that provide a rigorous mathematical definition of Feynman path integrals. (Received September 18, 2012)

1086-81-1157 **Chaobin Liu*** (cliu@bowiestate.edu), Bowie State University, Department of Mathematics, Bowie, MD 20715, and **Nelson Petulante** (npetulante@bowietste.edu), Bowie State University, Department of Mathematics, Bowie, MD 20715. *Asymptotic Behavior of Unitary Quantum Walks on the Half Line.* Preliminary report.

We investigate the limiting behavior associated with the specific model, as proposed by previous researchers, of a discrete unitary quantum walk (QW) on the set of non-negative integers. For every position node $x=0, 1, 2, 3, \dots$, as time t approaches infinity, we derive the probability $p(x)$ of finding the particle at x . Moreover, we specify explicitly the behavior of the weak limit of X_{-t}/t . (Received September 19, 2012)

1086-81-1189 **Jean Bourgain**, IAS, Princeton, NJ, **F. Alberto Grunbaum*** (grunbaum@math.berkeley.edu), UC Berkeley, Berkeley, CA 94720, **Luis Velazquez**, Universidad de Zaragoza, Zaragoza, Spain, **Albert Werner**, Institute for Theoretical Physics, Leibnitz University, Hannover, Germany, **Reinhard Werner**, Hannover, and **Jon Wilkening**, UC Berkeley, Berkeley, CA 94720. *Spectral analysis of state and site recurrence for discrete unitary evolutions.* Preliminary report.

The notion of state recurrence introduced in (GVWW) F. A. Grünbaum, L. Velazquez, A. Werner and R. Werner is extended to consider site (or subspace) recurrence.

A characterization of recurrence is given in terms of the matrix valued Schur function associated to the spectral measure of the subspace in question.

We give a topological interpretation for the expected return time to a site along the lines of GVWW.

These results are illustrated with analytical computations for one dimensional quantum walks as well as with pictures in the case of a few two dimensional quantum walks extensively studied in the literature. (Received September 24, 2012)

1086-81-1338 **Michel L Lapidus*** (lapidus@math.ucr.edu), University of California, Department of Mathematics, 900 University Ave., Surge Bdg., Riverside, CA 92521-0135. *Results and Open Problems on Feynman's Operational Calculus.*

We shall survey several results and propose several open problems connected with Feynman's operational calculus for noncommuting operators. Some of this work is closely connected with aspects of a book in preparation jointly with Gerald Johnson and Lance Nielsen and entitled "Feynman's Operational Calculus and Beyond: Noncommutativity and Time-Ordering", as well as to aspects of an earlier book by Gerald Johnson and the presenter and entitled "The Feynman Integral and Feynman's Operational Calculus" (Oxford University Press, Oxford Mathematical Monographs, 2000; corrected printing and paperback edition, 2002). (Received September 21, 2012)

1086-81-1459 **Matthew Largo**, **Sheng Xiong*** (sxiong@pitt.edu) and **Wei-Shih Yang**. *Quantum random walks with open decoherence.* Preliminary report.

I will discuss discrete-time quantum random walks on graphs under partial open decoherence with parameter p . In this talk, I will present the results of my work collaborated with Matthew Largo and Wei-Shih Yang on the limiting distribution of partial open quantum random walks with parameter p on an integer lattice. (Received September 22, 2012)

1086-81-1461 **Shimao Fan**, **Zhiyong Feng**, **Sheng Xiong** and **Wei-Shih Yang*** (yang@temple.edu). *Quantum random walks under decoherence.*

In this talk, I will discuss discrete-time quantum random walks on integer lattice subject to various decoherence. The general idea is that the limiting distribution of the rescaled position probability distribution converges to a continuous convex combination of normal distributions under the condition that if 1 is the largest eigenvalue of the superoperator with multiplicity one. In particular, I will present our results for the case of coin-space decoherence. (Received September 22, 2012)

1086-81-1765 **Yusuke Ide*** (ide@kanagawa-u.ac.jp). *Time averaged distribution of discrete time quantum walks on the path.*

The discrete time quantum walk (DTQW) which is a quantum counterpart of the random walk (RW) plays important roles in various fields such as the quantum information theory. In my talk, based on [1], I focus

on relationships between the time averaged limit distribution and spectrum of the time evolution operator of DTQWs on the (finite) path.

[1] Y. Ide, N. Konno, E. Segawa (2012), Time averaged distribution of a discrete-time quantum walk on the line, *Quantum Information Processing* 11(5), 1207-1218. (Received September 24, 2012)

1086-81-1848 **Michael G Dombroski*** (dombroskiSTM11@verizon.net), CA. *A Discrete, Compact, Matrix, Space-Time Representation – An Example*. Preliminary report.

In a previous paper, (1063-81-112, Abstracts, Volume 31, Issue 4), “A Catalog of **IJK** and **InJnKn** Matrix Base States with **TriKets**©”, 384 **TriKets** were cataloged. This paper presents an empirically-found, extremely compact, discrete, completely real, matrix space-time representation:

$$zxyt := \begin{pmatrix} z_1 & x_1 & y_1 & t_1 \\ y_2 & z_2 & x_2 & t_2 \\ x_3 & y_3 & z_3 & t_3 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

Note the space-time symmetry: three vectors (zxy) plus one scalar (t). This representation, called here, the ZXYT©, or ZX©, takes advantage of the IJK© notation to give compact, in-phase, functional forms of these matrices. *This is the basis for the examination of the hypothesis that there exists a finite, real, extremely compact, natural mathematics that describes the physical universe exactly.* There are 12 sets of three, 3 × 3 Universal Base States, UBS© (pre-preons?). Each set provides an Environ©(ment) containing nine of the UBS. There are 12 Environs: lower case (aa, bb, cc, dd, ee, ff) plus Upper Case (AA, etc). Pairs of complementary, mathematically real, “Toy Lagrangian Amplitudes©”, for example, ⟨Mbi2|Pbi5⟩ = (±)|Pbi2⟩⟨Mbi5| generate the symmetric, anti-symmetric, or zero eigenfunctions (boson, fermion, zero: supersymmetry?). There are two types of matrices: Q and L. Note that all pairs are *independent of scalar time* in zxyt. A natural three-dimensionality emerges from the *same sign pattern* for each I, J, K, and i, j, k matrix set (e,mu,tau?). The Planck Level is assumed. <http://dombroskiSTM.org/com/net>

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1086-81-2445 **Marco Lanzagorta*** (marco.lanzagorta@nrl.navy.mil), US Naval Research Laboratory, 4555 Overlook Ave. SW, Washington, DC 20375. *Group Theoretic Analysis of Relativistic Quantum Walks*. Preliminary report.

It is known that discrete-time quantum walks and relativistic quantum dynamics in 1+1 spacetime for spin-0 and spin-1/2 particles have a similar mathematical structure. However, there are many unanswered questions: is this a coincidence? What is the optimal extension to 4-D spacetime? Do the same similitude emerges for a spin-1 particle (e.g. a massless photon)? To provide a mathematical framework to answer these questions, it is important to recall that the Klein-Gordon (Spin-0), Dirac (spin-1/2), and Maxwell (massless spin-1) equations can be easily derived by invoking simple group theoretic arguments on the Poincare invariance of wave functions with extra degrees of freedom. Furthermore, these extra degrees of freedom are shown to correspond to the particle's spin. As a consequence, the algebraic structure and representations of the Poincare group ultimately dictate the dynamics of relativistic particles with arbitrary spin. In this paper we will discuss the group theoretic structure of discrete-time quantum walks that lead to relativistic quantum equations. In particular, we explore how discrete-time quantum walks are able to replicate the structure of the Poincare group and the right approach to formulate answers to the questions posed above. (Received September 25, 2012)

1086-81-2468 **Carl Gardner and Brance Hudzietz*** (bphudzie@asu.edu). *Molecular Radiative Cooling in Astrophysical Jet Simulations*. Preliminary report.

We investigate the radiative energy loss of several molecular compounds present in stellar nursery molecular clouds for the purpose of improving astrophysical jet simulations. The compounds H_2 , H_2O , and CO were examined due to their relatively high abundance in regions similar to the Eta Carina nebula. A molecular cooling model from the literature was utilized to approximate the rotational and vibrational transitions of these three compounds under collisional excitation. We found that molecular cooling is an important factor for jet/cloud interactions in the low temperature regime ($T < 10,000K$), when compared to the atomic cooling in our existing model. (Received September 25, 2012)

1086-81-2528 **Angelica Rae Deibel*** (adeibel@asu.edu), **Kevin Schwenkler**, **Laura Veith** and **Yevgeniy Kovchegov**. *Time-Inhomogeneous Quantum Walks*.

Quantum walks, the quantum analog to classical random walks, are expected to be of great use in quantum computing applications, but thus far only the simplest examples have been thoroughly studied. A quantum walk can be completely described by a system of recurrence relations; the amplitude of the particle present at location

n at time t depends on the amplitudes present at locations $n-1$ and $n+1$ at time $t-1$. This system of recurrence relations can be equivalently represented by a matrix called a coin operator. Most is known about homogeneous quantum walks, whose coin operators are constant with respect to both spatial and temporal variables. We study time-inhomogeneous quantum walks, whose coin operators are time-dependent. We solve the resulting system of recurrence relations numerically, and analytically where possible, to obtain a description of the evolution and asymptotic behavior of the time-inhomogeneous quantum walk. (Received September 25, 2012)

82 ► *Statistical mechanics, structure of matter*

1086-82-294 **Mei Yin*** (myin@math.utexas.edu), Department of Mathematics, University of Texas at Austin, 2515 Speedway Stop C1200, Austin, TX 78712. *A Markov chain approach to renormalization group transformations.*

We aim at an explicit characterization of the renormalized Hamiltonian after decimation transformation of a one-dimensional Ising-type Hamiltonian with a nearest-neighbor interaction and a magnetic field term. To facilitate a deeper understanding of the decimation effect, we translate the renormalization flow on the Ising Hamiltonian into a flow on the associated Markov chains through the Markov-Gibbs equivalence. Two different methods are used to verify the well-known conjecture that the eigenvalues of the linearization of this renormalization transformation about the fixed point bear important information about all six of the critical exponents. This illustrates the universality property of the renormalization group map in this case. (Received August 16, 2012)

1086-82-802 **Jacob W Chapman*** (jchapman@uab.edu), UAB Department of Mathematics, CH 452, 1720 2nd Avenue S., Birmingham, AL 35294, and **Günter Stolz**. *Localization for a Non-Monotone Anderson-Type Model.* Preliminary report.

A non-monotone random block operator arising from quantum spin systems will be introduced. The recent work of Elgart, Shamis, and Sodin, making use of the fractional moment method, implies dynamical localization for this operator, but only at large disorder. Being closely connected to the 1D Anderson model, this block operator should also exhibit dynamical localization at small disorder. We will present our results on positivity of the Lyapunov exponents and the current state of our proof of localization based on a multiscale analysis approach. (Received September 13, 2012)

1086-82-2992 **Ngoc T. Do** (dothanh@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, Texas 77843-3368, and **Peter Kuchment*** (kuchment@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, Texas 77843-3368. *Quantum graph models of graphyne structures.* Preliminary report.

Graphyne is the common name for several suggested mono-layer carbon allotropes, which carry a promise of surpassing graphene in terms of their interesting properties. We will present a study of spectra of invariant Schrödinger operators on some graphyne structures. (Received September 30, 2012)

83 ► *Relativity and gravitational theory*

1086-83-1473 **Alberto Mokak Tegui*** (alberto@math.duke.edu), 2440 north boulevard, apt 3302, Houston, TX 77098. *Stochastic Gravitational Microlensing: Mathematical Theory and Applications.*

Stochastic microlensing is a powerful tool used to probe the nature of dark matter on galactic scale. I develop general mathematical framework for stochastic microlensing and characterize the stochastic behavior of fundamental physical quantities. Next I study two specific lensing scenarios: The uniform stars' distribution and the spatial stars' distribution with general mass spectrum. In each case, I present both exact and asymptotic properties of random lensing observables. These results allow us to make testable predictions about dark matter substructure. I finish with a look toward further generalization of my results. (Received September 22, 2012)

85 ► *Astronomy and astrophysics*

1086-85-1501 **Lindsay Grayson*** (graysonl2@mymail.nku.edu) and **Kirk Wallace** (wallacek1@mymail.nku.edu). *Assessing the Chaotic Nature of Interstellar Magnetic Fields.*

The interstellar medium contains a magnetic field whose strong turbulent component plays a crucial role in how high-energy cosmic rays influence the formation of stars and planets. Due to the turbulent nature of the magnetic field, it is known that two particles injected into a field with the same initial velocities but slightly different initial positions will subsequently follow very different paths. Mathematically, we can quantify this effect by calculating Lyapunov exponents. Models for the magnetic field consist of sums of Alfvén waves, as predicted by linear magnetohydrodynamic theory. We calculated the Lyapunov exponents numerically for the fields and found one positive exponent, indicating the chaotic nature of the field lines, each time. Since each model consists of N randomly directed Alfvén waves, we ran simulations to obtain a distribution of largest Lyapunov exponents for each value of N . We found that the mean largest Lyapunov exponent increases with N , indicating that the length scale over which information from the initial condition is lost is shrinking. For N greater than 100, the mean largest Lyapunov exponent plateaus, meaning that a model consisting of 100 waves adequately describes the chaotic nature of the field. (Received September 22, 2012)

86 ► *Geophysics*

1086-86-2 **Emily F Shuckburgh*** (emsh@bas.ac.uk), High Cross, Madingley Rd, Cambridge, CB3 0ET, United Kingdom. *Using mathematics to better understand the Earth's climate.*

One of the most important scientific challenges of our time is to improve our understanding of the Earth's climate - past, present and future. Mathematics lies at the heart of many of our endeavors to progress this understanding. In this talk I will discuss some of the ways in which we have taken ideas and concepts from different branches of mathematics, from dynamical systems to statistics, and applied them to explore key processes in the atmosphere and oceans. For example, I will describe how recently we have been literally applying mathematics to the ocean by deploying floats in the Southern Ocean to map unstable manifolds and calculate Lyapunov exponents. This has improved our understanding of mixing in the ocean, something which is critical for our ability to model and predict future climate. (Received September 24, 2012)

1086-86-58 **Kenneth M. Golden***, University of Utah, Salt Lake City, UT. *Mathematics and the melting polar ice caps.*

In the summer of 2012, the area of the Arctic Ocean covered by sea ice reached its lowest level ever recorded in more than three decades of satellite measurements. In fact, compared to the 1980's and 1990's, this represents a loss of almost half of the summer Arctic sea ice pack. While global climate models generally predict sea ice declines over the 21st century, the precipitous losses observed so far have significantly outpaced most projections. In this lecture I will discuss how mathematical models of composite materials and statistical physics are being used to study key sea ice processes such as its freezing and melting. Such processes must be better understood to improve projections of the fate of Earth's sea ice packs, and the response of polar ecosystems. Video from recent Antarctic expeditions where we measured related sea ice properties will be shown. (Received June 25, 2012)

1086-86-360 **Samuel S Shen*** (shen@math.sdsu.edu), Department of Mathematics and Statistics, San Diego State University, San Diego, CA 92182. *Trends, hottest and coldest years, climate regimes, decadal variations, and uncertainties of the United States temperature and precipitation since 1895.*

This lecture discusses six different climate regimes of the contiguous United States (US) according to the US Historical Climatology Network Version 2 (USHCN V2) data (T_{\max} , T_{\min} , T_{mean} , and precipitation) from 1895-current: 1895-1930 (cold), 1931-1960 (warm), 1961-1985 (cold), 1986-2010 (warm), 1895-1970 (dry), and 1971-2010 (wet). The temperature and precipitation data also imply different causes and consequences between the 1930s Dust Bowl warming and the latest warming in the last three decades. The roles of the Pacific and Atlantic sea surface temperature distributions are analyzed for the three major drought events since 1895: the 1930s mega drought, the 1950s severe drought, and the 1998-2002 major drought. The lecture will also discuss the sampling error variances of gridded monthly (USHCN V2). Our analysis assesses uncertainties, trends, and the rankings of the hottest and coldest years for the contiguous United States since 1895. From 1895-current, every month from January to December has a positive linear trend. February has the largest trend of 0.162 deg

C per decade, and September has the smallest at 0.020 deg C per decade. The three hottest (coldest) years measured by Tmax over the US were ranked as 1934, 2006, and 1999 (1912, 1917, and 1903). (Received August 25, 2012)

1086-86-384 **Ka-Kit Tung*** (ktung@uw.edu), Guggenheim Hall, Box 352420, Seattle, WA 98195.
Deducing anthropogenic global warming trend.

Interest in man-made global warming draws attention to the extraction of anthropogenic global warming trend in observational data. Currently accepted value is approximately 0.17 C per decade since 1979. We show that the deduction of the warming trend is often contaminated by the presence of a multi-decadal oscillation. Analysis of such a low-frequency oscillation, of 70-year period, is hampered by the shortness of available of global climate record, the longest of which is 162 years, containing only 2.5 cycles. We discuss the mathematics and statistics involved in extracting multi-decadal oscillations in climate records, and the impact of the result on the deduced anthropogenic warming trend. (Received August 27, 2012)

1086-86-1091 **W. Van Snyder*** (van.snyder@jpl.nasa.gov), 4800 Oak Grove Drive, Mail Stop 183-701, Pasadena, CA 91109-8099. *Combining line-by-line and pre-frequency-averaged models in the radiative-transfer equation.*

The clear-sky non-scattering radiative-transfer equation describes the propagation of radiation through a cloud-free atmosphere. In remote sensing, it is not uncommon to measure radiation from the atmosphere using a receiver that has a broader band than a spectral line. In these cases, one evaluates the equation for several frequencies, to model spectral lines accurately, and then averages the results as weighted by the channel's response. For atmospheric constituents that have small spectral variation within the filter, it is more efficient to pre-compute the absorption cross section and average that as weighted by the channel's response. The presentation describes how to combine the two methods to achieve accurate results quickly. (Received September 18, 2012)

1086-86-1113 **Christian Blick*** (blick@mathematik.uni-kl.de), Dipl.-Math, M.Sc. Christian Blick, University of Kaiserslautern, Department of Mathematics, 67653 Kaiserslautern, Germany.
3D-Wavelet Postprocessing of Seismic Data.

3D-wavelets are constructed by regularization of the fundamental solution of the Helmholtz equation in order to decorrelate seismic records used for ground probing. The resulting multiresolution procedure gives space decorrelated information about rock formation, depending on the choice of specific parameters used in acoustic wave propagation. (Received September 19, 2012)

1086-86-1200 **Joerg Kuhnert**, Fraunhofer ITWM, Fraunhofer-Platz 1, 67663 Kaiserslautern, Germany, and **Isabel Ostermann***, Fraunhofer ITWM, Fraunhofer-Platz 1, 67663 Kaiserslautern, Germany. *The Finite Pointset Method (FPM) and an Application in Soil Mechanics.*
Preliminary report.

The Finite Pointset Method (FPM) is a meshfree approach to numerically solve (coupled) PDEs occurring in computational fluid dynamics and continuum mechanics. The geometry of the domain (fluid or solid) is represented by a cloud of numerical points which carry all the necessary information and move with the velocity of the material (Lagrangian approach). FPM is a generalized finite difference method: The strong solution of the considered problem is determined by direct approximation of the occurring differential operators. One of the latest applications of FPM is the simulation of triaxial tests in soil mechanics with the material law of barodesy developed by the Division of Geotechnical and Tunnel Engineering at the University of Innsbruck. In soil mechanics the development of appropriate material laws for granular media is important for the research on their mechanical behavior and the development of suitable test procedures to classify and realistically simulate soils. (Received September 20, 2012)

1086-86-1311 **William F. Langford*** (wlangfor@uoguelph.ca), Department of Mathematics and Statistics, University of Guelph, 50 Stone Road East, Guelph, ON N1G2W1, Canada, and **Gregory M. Lewis**. *Hadley Cell Changes in Today's Climate and Paleoclimates.*

A mathematical model has been constructed for the study of convection in a rotating hemispherical shell of fluid, with radial gravity and a pole-to-equator temperature gradient on the inner boundary. The fluid in the model satisfies the Navier-Stokes Boussinesq PDE. For moderately strong values of the temperature gradient, convection cells appear that resemble the Hadley, Ferrel and polar cells of the present day climate of the Earth. The model reproduces the trade winds, westerlies, jet stream and polar easterlies of today's climate. As the temperature gradient is decreased, the Hadley cell slows in circulation velocity and expands poleward; also the jet stream moves poleward. All these changes have been observed recently in the atmosphere of Earth. Eventually, for still smaller values of the temperature gradient in the model, the Ferrel and polar cells disappear. Furthermore, the

model exhibits bistability and hysteresis. One of these two stable states resembles today's climate; the other is more like the "greenhouse" paleoclimate that existed on Earth for much of geological time. This is joint work with Greg Lewis of UOIT. (Received September 21, 2012)

1086-86-1377 **Guojun Gu***, Guojun.Gu-1@nasa.gov, and **Robert F. Adler**. *Diagnosing Variabilities/Changes in Global Precipitation Patterns during 1979-2010 Using Satellite-Based Measurements.*

This study summarizes our recent results of exploring how global precipitation and associated spatial patterns may vary on the interdecadal/long-term time scale during past three decades, specifically to what extent the spatial structures of precipitation changes could be related to surface temperature change. Satellite-/station- based measurements including the monthly precipitation product from the Global Precipitation Climatology Project (GPCP) and the SSM/I&SSMIS oceanic columnar water vapor are applied. Global mean surface temperature have been increasing during the time period. However, the water vapor and precipitation patterns of change do not reflect the pattern of surface warming, in particular in the tropical Pacific basin. Hence in addition to global surface warming likely due to anthropogenic forcing, other natural variabilities have also played a role. EOF analyses of longer-record (1949-2010) SST anomalies within the Pacific basin (60NS) and over the global oceans confirm the existence of a strong climate regime shift around 1998/1999, which might be associated with the Pacific Decadal Variability (PDV). Therefore, the observed linear changes/trends in precipitation and tropospheric water vapor result from a combined impact of global mean surface warming and PDV. (Received September 21, 2012)

1086-86-1522 **A. C. Fowler*** (andrew.fowler@ul.ie), MACSI, University of Limerick, Limerick, Ireland. *Sub-aerial and sub-glacial stream flow.*

The evolution of river channels and hillslope topography is described by Smith-Bretherton theory, consisting of two coupled partial differential equations for ground surface elevation s and water flow depth h . Asymptotic reduction of the model leads to a single degenerate non-linear reaction-diffusion equation for h , coupled with an integral constraint. Solutions immediately become of finite support and reach a stable steady state, representing a stream channel of self-determined width. A similar theory describes subglacial water flow beneath ice streams, with the added complication that the glacial ice also moulds the subglacial topography. (Received September 23, 2012)

1086-86-1950 **William R. Boos***, PO Box 208109, New Haven, CT 06520-8109. *Monsoons and the thermodynamic state of proximal deserts.*

Here we show that monsoon precipitation is influenced by the thermodynamic state of adjacent deserts, and provide an example of a relevant bias in the numerical models used to simulate next-century climate. We begin by examining observed monsoons in a convective quasi-equilibrium framework, in which near-surface entropy maxima are diagnostically related to the location and intensity of monsoon precipitation. Local entropy minima are located over adjacent deserts, and these minima covary interannually with monsoon precipitation. One exception is the South Asian monsoon, in which topography seems to insulate the thermal maximum from the influence of nearby deserts. But the smoothed topography used in almost all models participating in the Coupled Model Intercomparison Project allows too much desert air to penetrate the monsoon thermal maximum. This produces a negative bias in Indian monsoon precipitation in simulations of modern climate; increasing horizontal moisture gradients make this bias even stronger in simulations of next-century climate. This highlights the need for greater understanding of interactions between monsoons and adjacent deserts. (Received September 24, 2012)

1086-86-2046 **Ludmila Bouchteïn*** (ludmila.bouchteïn@gmail.com), Rua Anchieta 4715, bloco K, ap.402, Pelotas, RS 96015-420, Brazil, and **Andrei Bouchteïn**. *On well-posed problems in adjustment of atmospheric data.*

An adjustment of the initial data for atmospheric models usually leads to a system of time-independent partial differential equations, which express the physical balance conditions. A general problem in solving such diagnostic relations is non-ellipticity of the differential systems for some atmospheric conditions that does not allow us to formulate well posed boundary value problems. The classical example of the nonlinear balance equation for the middle troposphere can illustrate this situation: this equation is elliptic for unknown pressure and given stream function, but it is of the Monge-Ampere type if the pressure is given and stream function is to be found. In the latter case, the equation loses ellipticity under certain condition on the Laplacian of the pressure function, which corresponds to impossibility to solve boundary-value problem for the balance equation in the regions with strong anticyclonic formations. In this study, we present the ellipticity conditions for more complex differential systems

of nonlinear adjustment. Based on these results, we show distribution of non-elliptic regions in the gridded data of the actual atmospheric fields for different forms of the balance equations. (Received September 24, 2012)

1086-86-2057 **Andrei Bourchtein*** (bourchtein@gmail.com), Rua Anchieta 4715, bloco K, ap.402, Pelotas, RS 96015-420, Brazil, and **Ludmila Bourchtein**. *Scale-adaptive numerical scheme for atmospheric modeling*.

The atmosphere is a complex system supporting processes of different space and time scales. The corresponding three-dimensional mathematical models of the atmosphere contain multi-scale solutions with fast and slow components. It is well-known that the fastest atmospheric waves do not contain any significant part of the atmospheric energy, while relatively slow synoptic processes carry the main part of the available energy. Since differential approximations, which filter out fast waves, introduce distortions to the main physical modes, the problem of stiffness of the complete mathematical models of atmospheric dynamics should be addressed in a design of numerical scheme. In this study, a semi-implicit finite difference scheme is proposed for the atmospheric model based on the Euler equations. The fast acoustic and gravity waves are approximated implicitly and with lower accuracy, while slow advective terms and Rossby modes are treated explicitly and with higher order of approximation. The linear stability of the proposed scheme is analyzed and it is shown that the time step can be chosen in accordance with the physical requirements. The numerical experiments with actual atmospheric data are performed and the results of forecasts are compared with those of conventional schemes. (Received September 24, 2012)

1086-86-2073 **Adrean A Webb*** (adrean.webb@colorado.edu), University of Colorado at Boulder, CIRES, Box 216 UCB, Boulder, CO 80309-0216, and **Baylor Fox-Kemper** (bfk@colorado.edu). *An unstructured approach to ocean wave modelling*. Preliminary report.

Ocean surface gravity waves are an important component of the atmospheric and oceanic boundary layer and the inclusion of such in a global climate model has the potential to correct model biases and improve air-sea interactions. Current wave-generation models used for weather forecasting include extensive physics and parametrizations but they are computationally expensive for long climate runs. In addition, these models use a grid that is singular at the poles, making them ill-suited for studying polar-ice-free scenarios. As a result, an unstructured node approach using radial basis functions is currently being explored. With this method, it is possible to remove the grid singularity, decrease computational costs, and run in parallel. (Received September 24, 2012)

1086-86-2393 **Guang Zhang*** (gzhang@ucsd.edu), 9500 Gilman Dr., La Jolla, CA 92093-0221, and **Xiaoliang Song**, 9500 Gilman Dr., La Jolla, CA 92093-0221. *Convection Microphysics and its Interaction with Aerosols and Climate in a Global Climate Model*.

A physically-based two-moment microphysics parameterization scheme for convective clouds is developed and evaluated in the National Center for Atmospheric Research (NCAR) Community Atmosphere Model CAM5 to improve the representation of convective clouds and their interaction with large-scale clouds and aerosols. The scheme is linked to aerosols through cloud droplet activation and ice nucleation processes, and to large-scale cloud parameterization through convective detrainment of cloud liquid/ice water content and droplet/crystal number concentration. A multi-year simulation with the new convective microphysics scheme shows that both cloud liquid/ice water content and droplet/crystal number concentrations are in good agreement with observations. Moreover, the microphysics scheme is able to represent the aerosol effects on convective clouds such as the suppression of warm rain formation and enhancement of freezing when aerosol loading is increased. Implications of aerosol-convection interaction on climate change will be discussed in the presentation. (Received September 25, 2012)

1086-86-2453 **Andrew J Majda** and **Samuel N Stechmann***, University of Wisconsin-Madison. *The Skeleton of the Madden-Julian Oscillation: A Nonlinear Oscillator Model*.

The Madden-Julian Oscillation (MJO) is a propagating envelope of complex multi-scale convection/storms in the tropics. With characteristic scales of 30-60 days and 20,000 km, it significantly affects El Niño, monsoons, hurricanes, and midlatitude predictability. Despite its importance, no theory for the MJO has yet been generally accepted, and climate models typically have inadequate representations of it.

In this talk, a minimal, nonlinear oscillator model is analyzed for the MJO “skeleton,” i.e., its fundamental features on intraseasonal/planetary scales: (i) slow eastward phase speed of roughly 5 m/s, (ii) peculiar dispersion relation $d\omega/dk \approx 0$, and (iii) horizontal quadrupole vortex structure. Originally proposed in recent work by the authors, the fundamental mechanism involves neutrally stable interactions between moisture, convection,

and equatorial fluid dynamics. Linear theory and nonlinear simulations will be presented. In addition, it is also shown that the nonlinear model conserves a total energy that includes a contribution from the convective activity. (Received September 25, 2012)

1086-86-2488 **Kimberly D Leung*** (kimberly.leung@science.sdsu.edu), **Aneesh Subramanian** (acsuabram@ucsd.edu), **Guang Zhang** (gzhang@ucsd.edu) and **Samuel Shen** (shen@math.sdsu.edu). *Stochastic Differential Equation Modeling of Precipitation in Convection.*

A simple stochastic model is used to model the transition to strong convection. Recent studies have used statistical measures inferred from observational data to characterize this transition at a critical value of column water vapor (CWV), around which there is a sharp transition in mean precipitation and a peak in precipitation variance. The probability density of precipitation events can be approximated by a power law, and those of CWV and precipitation autocorrelation functions by exponential and power-law decays, respectively. However, the parameters used in the variable functions are derived from a combination of empirical and theoretical estimates. In this study, the statistics of the transition as well as other variables in the model are analyzed with respect to satellite and field observations to estimate the parameters in the stochastic model. We present results from analysis comparing the statistical behavior of the variables in the model to those in observations. This parameterization includes three stochastic components: a stochastic trigger that turns the precipitation state on and off (a two-state Markov jump process), and stochastic closures representing variability in precipitation and other forcing (represented by Gaussian white noise). (Received September 25, 2012)

1086-86-2493 **Dimitrios Giannakis*** (dimitris@cims.nyu.edu), 251 Mercer St, New York, NY 10012. *Capturing intermittent and low-frequency variability in high-dimensional data through nonlinear Laplacian spectral analysis.*

Nonlinear Laplacian spectral analysis (NLSA) is a method for spatiotemporal analysis of high-dimensional data, which represents spatial and temporal patterns through singular value decomposition of a family of maps acting on scalar functions on the nonlinear data manifold. Through the use of orthogonal basis functions (determined by means of graph Laplace-Beltrami eigenfunction algorithms) and time-lagged embedding, NLSA captures intermittency, rare events, and other nonlinear dynamical features which are not accessible through classical linear approaches such as singular spectrum analysis. We present applications of NLSA to detection of decadal and intermittent variability in the North Pacific sector of comprehensive climate models, and multiscale physical modes of the Madden-Julian Oscillation in infrared brightness temperature satellite data.

In collaboration with Andrew Majda (Courant) and Wen-wen Tung (Purdue). (Received September 25, 2012)

1086-86-2624 **Jin Sun*** (jin@coas.oregonstate.edu), 104 CEOAS Admin Building, Oregon State University, Corvallis, OR 97330, **Gary D Egbert** (egbert@coas.oregonstate.edu), 104 CEOAS Admin Building, Oregon State University, Corvallis, OR 97330, and **Anna Kelbert** (anya@coas.oregonstate.edu), 104 CEOAS Admin Building, Oregon State University, Corvallis, OR 97330. *Explicit current source modeling in global geomagnetic induction: forward and inverse problems.*

Global geomagnetic induction studies Earth's induction response to external current sources and make inferences about the deep conductivity structures of the solid Earth. Modeling of the external current sources has long relied on Gaussian coefficients, which obscure relationships between the true physical currents and the equivalent representations. Using representations based on Green's functions, such relationships may be clarified. Separation of internal, external and radial current sources is explicitly obtained. Inadequate source modeling has long plagued global induction: With a highly simplified P10 dipole model, geomagnetic data are limited in period, latitude and space weather conditions where such model may be tenable. To overcome these limitations, we propose a simultaneous source-conductivity estimation: Our approach involves 1) principal component analysis of observatory data to extract dominating spatial variation modes at periods from 2 to 100 days; 2) source modeling and estimation from the data spatial modes, using explicit currents under quasi-dipole coordinates; and 3) 3D conductivity anomaly estimation with fixed sources. The two estimation procedures are iterated to explore the trade-offs between conductivity anomalies and source complications. (Received September 25, 2012)

1086-86-2693 **J. David Neelin*** (neelin@atmos.ucla.edu), **Mickael Chekroun**, **Annalisa Bracco**, **Hao Luo**, **James C. McWilliams**, **Dmitri Kondrashov**, **Michael Ghil**, **Sandeep Sahany** and **Richard Neale**. *Fundamentals of parameter sensitivity in climate models.*

The representation of subgrid scale processes introduces many poorly constrained parameters into mathematical representations of the climate system, contributing substantial uncertainty in model projections of climate

change. For example, simulations of regional scale precipitation change and of climate variability such as El Niño exhibit substantial scatter across model ensembles. Is the underlying parameter dependence rough or approximately smooth; how strong is the nonlinearity? Requirements for accuracy in different regions and variables yield a multi-objective optimization problem of high dimension. Are the resulting trade-offs more limiting than those associated with nonlinear parameter dependence? Results from current global climate models appear to be reasonably smooth, but with substantial nonlinearity over the feasible parameter range in key variables. To understand potential limitations to smooth approximations, this is contrasted with rough parameter dependence in an intermediate complexity model of El Niño. This motivates an approach based on estimating Ruelle-Pollicott resonances filtered through a climate observable in a related talk by M. Chekroun. Finally, a practical example will be provided of improving constraints on deep convective parameterization. (Received September 25, 2012)

90 ► *Operations research, mathematical programming*

1086-90-184 **Sarah Bass, Katarina Gagic, Tim Hsu, Anh Nguyen, Charles Petersen*** (petersenc19@yahoo.com), **Jim Quach, Jonathan Reyles, Cliff Sandwick and Karen Wu.** *New partition algorithms for 1-D event data.* Preliminary report.

This talk is on work done as part of the Center for Applied Mathematics, Computation, and Statistics (CAMCOS) at SJSU. We consider the analysis of 1-D *event data* (i.e., a list of times at which some event, like the detection of a photon, happens). Specifically, we consider the problem of optimally *partitioning* an interval of time over which event data is collected into *blocks* of roughly constant event rate. A previous CAMCOS team developed a provably optimal algorithm to solve this problem that runs in $O(N^2)$ time.

We present several new algorithms for solving the partitioning problem and variants. Most notably, we describe an algorithm, based on the idea of *local changepoint detection*, that often seems to work significantly faster (on the order of 3–8 times faster) on large data sets than the existing algorithm does, at the cost of a possible loss of accuracy. We also discuss work in progress and future directions. (Received August 03, 2012)

1086-90-254 **Vikramjeet Singh*** (vikram31782@gmail.com), Lovely Professional University, Jalandhar-Delhi G. T.Road(NH-1),Block-34-201, Department of Mathematics, UID-12087, Phagwara,Punjab, 144402, India. *Modeling and Analysis of an Inventory System with Ramp Type Demand Rate and Backlogging.*

In this paper an inventory model for deteriorating and ameliorating items with variable holding cost has been developed. We considered the ameliorating items which follow time varying demand with ramp type pattern. Shortages are permitted and partially back-ordered. The back-ordering fraction is taken to be decreasing function of waiting time. Total cost of the system is formulated and optimal replenishment policy is derived, keeping in view the above factors of the system. (Received August 14, 2012)

1086-90-359 **Chris Aholt, Sameer Agarwal and Rekha R Thomas*** (rrthomas@uw.edu). *The Triangulation Problem in Computer Vision.*

The triangulation problem in computer vision is the problem of reconstructing 3-dimensional scenes from a number of noisy 2-dimensional camera images. This problem lies nicely at the intersection of algebraic geometry and optimization and can be naturally modeled as finding the closest point to the given observation in an algebraic variety. I will demonstrate how algebra and combinatorics is used to find the constraints and how methods from convex and semidefinite optimization is used to solve the optimization problem to obtain reconstructions of very high accuracy. (Received August 25, 2012)

1086-90-840 **Matthias Köppe*** (mkoepp@math.ucdavis.edu), **Amitabh Basu, Robert Hildebrand and Marco Molinaro.** *The Gomory-Johnson infinite group problem: A 40-year update.*

I present new results on the Gomory-Johnson infinite group problem, which appear in joint papers with A. Basu, R. Hildebrand, M. Molinaro.

The infinite group problem is an infinite-dimensional abstraction of mixed-integer linear programs for the purpose of deriving cutting planes.

We give an algorithm for testing the extremality of minimal valid functions for the infinite group problem on R^1/Z^1 , that are piecewise linear (possibly discontinuous) with rational breakpoints. This is the first set of necessary and sufficient conditions, which can be tested algorithmically, for deciding extremality in this important class of valid minimal functions. We also present an interesting irrational function.

We also prove that any minimal valid function for the k -dimensional infinite group relaxation (on R^k/Z^k) that is piecewise linear with at most $k+1$ slopes and does not factor through a linear map with non-trivial kernel

is extreme. This generalizes the famous 2-slope theorem of Gomory and Johnson for $k = 1$, and a corresponding result by Cornuéjols and Molinaro for $k = 2$. (Received September 13, 2012)

1086-90-883 **Daniel Bienstock*** (dano@columbia.edu), Dept. of IEOR, Columbia University, 500 W 120th St, New York, NY 10027, and **Alexander Michalka** (admichalka@gmail.com), Dept. of IEOR, Columbia University, 500 W 120th St, New York, NY 10027. *Optimizing convex functions over non-convex sets.*

A recurring theme in optimization theory is that convexity (in the objective function and in the constraints) usually leads to provably good, i.e., polynomial-time, algorithms. However, many important problems in science and engineering inconveniently do not adhere to this prototype. Whereas the objective function is frequently convex (even quadratic), corresponding for example to least-squares estimation, or energy minimization, the constraints of the problem, which reflect fundamental physical or engineering relationships, are not convex. In such cases we would still prefer to leverage the techniques of convex optimization. Such a situation will ensue if, in the appropriate reformulation of the problem, we can solve the classical "separation problem" efficiently – that is to say, given an arbitrary vector which is not feasible, separate it from the feasible set by means of a linear inequality. In the non-convex case this cannot be done unless the problem is suitably reformulated. The emphasis on linear separating inequalities is justified in terms of numerical stability of the overall optimization algorithm, and solution speed. Thus we can leverage fast, robust, linear programming solvers. In this talk we describe ongoing work that develops this paradigm. (Received September 14, 2012)

1086-90-1041 **Ram U. Verma*** (verma99@msn.com). *The Epsilon-efficiency conditions for multiobjective fractional subset programming and generalized invex functions.* Preliminary report.

Based on the generalized invexity assumptions of n -set functions, some parametric and semi-parametric sufficient epsilon-optimality conditions for the multiobjective fractional subset programming problem are investigated. (Received September 18, 2012)

1086-90-1285 **Claire A Montgomery*** (claire.montgomery@oregonstate.edu). *Applications to wildfire and fire fuels management in forest landscape-level planning.* Preliminary report.

The forests of the western U.S. are adapted to light frequent burning by indigenous populations over the last 10 millennia. Changes brought by European settlement upset the long established balance in two ways: removal of indigenous populations from the landscape also removed purposeful use of fire during moderate weather conditions; aggressive suppression of subsequent wildfire led to structural changes in these forests which increase the likelihood of catastrophic fire that destroys vegetation and sometimes soil. Resources for mitigation are limited. But rapidly escalating fire suppression expenditures lend urgency to the call for decision support tools to identify optimal wildfire and forest fire fuel management strategies. The problem is complex because it is spatial, stochastic, and dynamic. Stochastic dynamic programming has been applied to highly stylized formulations of the problem, but quickly becomes intractable as units and options increase to realistic numbers. This paper reports ongoing research in which we attempt to apply approximate dynamic programming methods (aka reinforcement learning) to identify policies for efficient use of wildfire on a landscape in central Oregon to mitigate fuel loading and restore fire adapted forest conditions. (Received September 20, 2012)

1086-90-1511 **Rebecca Stockbridge*** (rstockbridge@math.arizona.edu) and **Guzin Bayraksan** (guzinb@sie.arizona.edu). *Bias reduction in optimality gap estimation for stochastic programs.*

Monte Carlo sampling-based estimators of optimality gaps for stochastic programs are known to be biased. We present a method for reducing the bias of the estimators produced by the Averaged Two-Replication Procedure (A2RP) via a probability metrics approach, which can be done in polynomial time in sample size. Theoretical and computational results will be highlighted. (Received September 26, 2012)

1086-90-1550 **Hongbo Dong, Hyemin Jeon, Jeff Linderoth*** (linderoth@wisc.edu) and **Andrew Miller**. *Mixed-Integer Nonlinear Programs with On-Off Constraints.*

We study optimization problems that have both nonlinear functional relationships between decision variables and 0-1 indicator variables that turn on and off these relationships. Problems of this class occur in a broad range of disciplines, including statistics, financial engineering, and engineering design. In this talk, we will describe strong relaxations and cutting planes for a substructure common to instances of these problems. Our primary focus will be on the case when the nonlinearities are quadratic. (Received September 23, 2012)

- 1086-90-1870 **Sofya Chepushtanova*** (chepusht@math.colostate.edu), 101 Weber Building Colorado State University, Fort Collins, CO 80523-1874, and **Michael Kirby**. *Hyperspectral Band Selection Using Sparse Support Vector Machines*.

In this research we explore an ℓ_1 -norm linear support vector machine (ℓ_1 -norm SVM) for the hyperspectral imagery band selection problem. The ℓ_1 -norm SVM constructs the optimal separating hyperplane between two classes of data points with maximum margin measured in ℓ_∞ -norm. The resulting optimization problem is in the form of a linear program which we solve using a primal dual interior point algorithm. The ℓ_1 -norm suppresses many components of the weight vector w , normal to the hyperplane, and the nonzero components in w indicate the spectral bands that are effective at separating the data. We propose a statistical framework for the band selection problem. Using the ℓ_1 -norm SVMs built on randomly chosen subsets of training data, we derive a sample of sparse weight vectors w . Then hypothesis testing is used to select and order the important bands by P -values. The behavior of the learning method is illustrated by modeling decision functions for classification of the AVIRIS Indian Pines data set. The models are tested on the full and reduced testing sets with high accuracy rates achieved on both. (Received September 24, 2012)

91 ► *Game theory, economics, social and behavioral sciences*

- 1086-91-56 **Jeff Suzuki*** (jeff_suzuki@yahoo.com), 235 South Riverside Road, Highland, NY 12528, and **Guillaume Jean**. *SAM and Jury Decisions: Should the Supreme Court Overturn Williams v. Florida?*

The traditional American jury consists of 12 jurors who must render a unanimous decision. However, the Supreme Court has ruled as constitutional 12-person juries with a quota of 9, and 6-person juries with a unanimity requirement. We use Thomas and Pollack's Sample Accuracy Model (SAM) to analyze these juries under various assumptions, and conclude that smaller juries and non-unanimous quotas present a serious threat to the application of justice in the legal system. (Received June 23, 2012)

- 1086-91-94 **Andrew Niedermaier*** (aniedermaier@janestreet.com), 1 New York Plaza, 33rd Floor, New York, NY 10004. *Colonel Blotto Returns*. Preliminary report.

Have you met Colonel Blotto? His task is a doozy: split his army of 100 soldiers and send them to fight at 10 different castles. The opposing army is also sending 100 soldiers to the same 10 castles. At each castle, the larger army wins. In order to maximize his (expected) number of castles won, should Blotto split his army evenly, or opt for an asymmetric strategy?

Four years ago I introduced the basic Blotto game to the Joint Meetings and invited the audience to play along. Now I want to share with you some results that I've seen over the past several years of playing Blotto with undergrads, high school olympiad champions, and Wall Street professionals.

From linear programming to game theory to genetic algorithms to marginal returns, I hope to show that Blotto can be used in the classroom as an enjoyable way to touch on a wide range of topics. (Received July 15, 2012)

- 1086-91-169 **Raymond N. Greenwell*** (matrng@hofstra.edu), Department of Mathematics, Hofstra University, Hempstead, NY 11549, and **Tadeusz Krauze** (tadeusz.k.krauze@hofstra.edu), Department of Sociology, Hofstra University, Hempstead, NY 11549. *Partially ordered sets and stratification*. Preliminary report.

We employ partially ordered sets to describe the stratification of a social system, using rank to define the strata. We present a simple method of computing the matrix corresponding to the Hasse diagram and prove its correctness. This methodology is applied to analyze the hierarchy of countries that have won at least one Olympic medal. Four different definitions of dominance are given, leading to four different hierarchies and Hasse diagrams. We also prove that any of these definitions preserve any ordering based on giving different weights to gold, silver, and bronze medals. We study dominance between adjacent strata and note how the system changes with time. We present a case analysis for Poland as an illustration of the set of data that can be computed for any country. (Received August 01, 2012)

- 1086-91-408 **Yang Jiao*** (yangjiao@sas.upenn.edu). *On the Sprague-Grundy Values of the \mathcal{F} -Wythoff Game*.

We examine the Sprague-Grundy values of \mathcal{F} -Wythoff, a restriction of Wythoff's game introduced by Ho, where the integer ratio of the pile sizes must be preserved if the same number of tokens is removed from both piles. We

answer two conjectures raised by Ho. First, we show that each column of Sprague-Grundy values is ultimately additively periodic. Second, we prove that every diagonal of Sprague-Grundy values contains all the nonnegative integers. We also investigate the asymptotic behavior of the sequence of positions attaining a given Sprague-Grundy value. (Received August 29, 2012)

1086-91-631 **Joshua Cape*** (jcape@cableone.net), **William Dearden** (wgd208@lehigh.edu), **William Gamber** (wlg02009@mymail.pomona.edu) and **Linh Nguyen** (nguyenlm@lafayette.edu). *Model-Implied Measures of Risk-Adjusted Returns in Stochastic Volatility Models.*

In finance, the rate of return is a performance measure used to compare financial instruments. With the adage no risk, no return in mind, rates of return can be better represented by attaching to them the associated risk describing the volatility of the return. Much of financial literature explores the derivation of risk-adjusted measures of return and aims to best characterize the performance of underlying financial instruments.

We use simulation to investigate the distributional properties of several risk-adjusted measures of return implied by the following three different stochastic volatility option pricing models: the Black-Scholes, Heston, and Bates models. We derive the necessary computational machinery—which is not published in the literature—and employ Monte Carlo methods in our approach. While the measures we consider have been well-researched in empirical studies of historical data, little work had been done to better understand the statistical properties of these measures within the context of stochastic option pricing models. We address this need in our analysis. Additionally, we assess model-implied differences between measures of return across different option pricing models. (Received September 09, 2012)

1086-91-740 **Alissa M Stafford*** (astaffo2@umd.edu). *In search of universal scaling functions in a financial market model.*

The standard models of economics and finance not only fail to predict sudden bubbles and crashes, they assume they cannot exist at all. This is because strong assumptions are made concerning the equilibrium nature of such systems and the absence of endogenous dynamics. This paper examines the endogenous dynamics of a non-standard market model in a preliminary attempt to understand the frequency with which bubbles and crashes occur. We identify 15 short time-intervals where significant price increases and decreases occur and focus upon the endogenous dynamics within them. Rescaling and averaging over these intervals identifies the average dynamical profile which in turn may help quantify the frequency of large financial and economic collapses. (This project was funded by the NSF REU at George Mason University) (Received September 11, 2012)

1086-91-760 **Daniel Jessie*** (djessie@uci.edu) and **Donald Saari**. *The Structure and Analysis of Games.*

For this game theory talk, rather than present a new application or solution concept, I will present an entirely new method for analyzing games. This method focuses on the global space of games to create a simple framework in which we can analyze and create solution concepts. Not only does this approach give a global perspective of the space of games, but it also reveals unique structural information about many different solution concepts. After developing the framework, I show how using this method sheds new light on both theoretical and experimental questions, both simplifying and expanding the current discussion. (Received September 12, 2012)

1086-91-765 **Donald G. Saari*** (dsaari@uci.edu), SSPB, University of California, Irvine, CA 92697-5100. *Reductionist argument: Unexpected mathematical complexities.*

The modeling of social interactions, or machine-human connections, or just about anything in the mathematical social sciences proves to be complicated. This suggests adopting versions of the “reductionist argument” that is widely used in the physical sciences: This is where a complex problem is reduced to several more tractable “parts.” But, as known in areas from nanotechnology to industrial organizations and social interactions, this approach can be accompanied with complexities. A mathematical reason for this is explained. (Received September 12, 2012)

1086-91-768 **Anthony Mendes*** (aamendes@calpoly.edu), Mathematics Department, 1 Grand Ave., Cal Poly, San Luis Obispo, CA 93407, and **Kent E. Morrison** (kmorriso@calpoly.edu), American Institute of Mathematics, 360 Portage Avenue, Palo Alto, CA 93406. *How to outguess your opponents.*

There are situations in everyday life in which people try to outguess one another. Visitors to the county fair can be asked to guess the number of jellybeans in a jar. In a sealed-bid auction, it might be desirable to bid closest to the value of a some object without guessing too high. Contestants on the American television program “The

Price Is Right” try to make better guesses on the price of household goods than their opponents. Assuming rational and intelligent guessers, what does the mathematics say should a person do?

We will look at the following game: players guess the value of a random real number selected using some probability density function known to all. The winner may be a player whose guess is closest in magnitude to the target or a winner can be a player coming closest without guessing higher than the target. We will talk about optimal strategies and exhibit some of them for small numbers of players. (Received September 12, 2012)

1086-91-769 **Donald G. Saari*** (dsaari@uci.edu), SSPB, University of California, Irvine, CA 92697-5100. *Symmetry groups to connect/extend voting theory results.*

To avoid voting results with undesired properties, seemingly disjoint conditions have been imposed: This includes the Nakamura number (a restriction on the number of alternatives), single-peaked and Sen’s condition (a restriction on admissible rankings), and Greenberg’s theorem (a restriction on the geometric number of issues). It is shown how to use symmetry groups to obtain a single theorem that explains, connects and significantly extends these results. (Received September 12, 2012)

1086-91-857 **Candace A. Ohm*** (cohm@math.fsu.edu). *A Game-Theoretic Approach to Manipulation.* Deception is a widespread phenomenon that occurs in humans as well as many other animal species. One form of deception is manipulation. Manipulation occurs when a signaler sends a message that alters the receiver’s expectations of its environment. In this presentation, I show how manipulation arises, explain how a signaler may send a manipulative message, and provide examples where manipulation is an evolutionary stable strategy. (Received September 14, 2012)

1086-91-879 **Maxim Bichuch and Stephan Sturm*** (ssturm@wpi.edu), Worcester Polytechnic Institut, Department of Mathematical Sciences, 100 Institute Road, Worcester, MA 01609. *Optimal Incentives for Delegated Portfolio Optimization.*

We study the problem of an investor who hires a fund manager to manage his wealth. The latter is paid by an incentive scheme based on the performance of the fund. Manager and investor have different risk aversions; the manager may invest in a financial market to form a portfolio optimal for his expected utility whereas the investor is free to choose the incentives – taking only into account that the manager is paid enough to accept the managing contract. We discuss the problem of existence of optimal incentives in general semimartingale models and give an assertive answer for some classes of incentive schemes. (Received September 16, 2012)

1086-91-938 **Davide Cervone, Christopher Hardin and William S. Zwicker*** (zwickerw@union.edu), Mathematics Department, Union College, Schenectady, NY 12308. *Higher order Condorcet cycles.* Preliminary report.

Suppose a ballot consists of a strict ranking of all alternatives in A , a finite set. When y is a single alternative and X is a set of alternatives, $P(y, X)$ stands for the set of voters who prefer y to all $x \in X$. In a *Condorcet cycle*, each alternative is beaten by some other; for each $x \in A$ there exists a y for which $P(y, \{x\})$ contains a majority of the voters. In a *uniform Condorcet cycle of order k* , for each set X of k alternatives $P(y, X)$ contains a majority for some y . If we weaken this condition, asking only that a y exist for which $P(y, x)$ contains a majority for each $x \in X$, we have a *Condorcet cycle of order k* . Which higher order cycles exist? Elkind, Lang, and Saffidine found a uniform order 2 cycle of size (15, 15) (15 alternatives, 15 voters). Using different methods we construct an order 2 cycle of size (7, 7), uniform order 2 cycles of sizes (11, 11) and (7, 21), and an order 3 cycle of size (19, ?). Order 2 cycles cannot have fewer than 7 alternatives and order k cycles exist for each $k \geq 2$. Do uniform order 3 cycles exist? (Received September 16, 2012)

1086-91-939 **Steven J. Brams*** (steven.brams@nyu.edu), Dept. of Politics, New York University, 19 West 4th St., 2nd Fl., New York, NY 10012, and **D. Marc Kilgour** (mkilgour@wlu.ca), Dept. of Mathematics, Wilfrid Laurier University, Waterloo, Ontario N2L 3C5, Canada. *Inducible Games: Using Tit-for-Tat to Stabilize Outcomes.* Preliminary report.

Assume it is known that one player in a 2x2 game can detect the strategy choice of its opponent with some probability before play commences. We formulate conditions under which the detector can, by credibly committing to a strategy of probabilistic tit-for-tat (based on its imperfect detector), induce an outcome favorable to itself. A non-Nash, Pareto-optimal outcome is inducible—that is, it can be stabilized via probabilistic tit-for-tat—in 20 of the 57 distinct 2x2 strict ordinal games without a mutually best outcome (35 percent). Sometimes the inducement is “weak,” but more often it is “strong.” As a case study, we consider the current conflict between Israel and Iran over Iran’s possible development of nuclear weapons and show that Israel’s credible commitment to probabilistic tit-for-tat can, with sufficiently accurate intelligence, induce a cooperative choice by Iran in one but not the other of two plausible games that model this conflict. (Received September 16, 2012)

1086-91-992 **Aden O Ahmed*** (aden.ahmed@tamuk.edu), 700 University BLVD, MSC 172, Kingsville, TX 78363-8202. *Best Reply Analysis in Two Person Games.*

This talk concerns an application of the normed real division algebra of the quaternions in the theory of quantum games. One of the main tasks in game theory is the identification of potential Nash equilibria of a given game. In mathematical terms, classical games are just payoff functions. Quantum games are particular extensions of classical games.

In this work, we find particular use for a maximally entangled initial state that produces a quantized version of two player two strategy games. When applied to a variant of the game of Chicken, our theory shows that new equilibria manifest themselves and these equilibria are often superior to known equilibria. (Received September 17, 2012)

1086-91-1079 **Jan Rychtar*** (rychtar@uncg.edu), University of North Carolina at Greensboro, Greensboro, NC 27412. *The effect of information asymmetry in Producer-Scrounger games.*

The biologically motivated Producer-Scrounger game-theoretical model deals with the following situation. One individual finds a resource and starts using it. Sometimes later, before the resource has been completely used, a second individual appears and attempts to use the same resource. The individuals could either 1) split the resource evenly, 2) fight for it, or 3) one of them can give it up. We will study the effect of information asymmetry. It is conceivable that the first individual has better knowledge about the resource than the one that joins later. However, contrary to any intuition, a careful analysis reveals that having more information yields to giving up more often, and consequently getting lower payoffs. This quite surprising result could mean that too much knowledge hurt. Yet, the most important feature is that even the second individual knows something – it knows that the first one knows. Hence, at least to some individuals, knowledge can be beneficial after all. (Received September 18, 2012)

1086-91-1092 **Cameron Parker*** (cparker@sandiego.edu), 5998 Alcala Park, San Diego, CA 92110. *The Influence Relation for Ternary Voting Games.*

Although simple games are very useful in modeling decision-making bodies, they allow each voter only two choices: to support or oppose a measure. This restriction ignores that voters often have the ability to abstain from voting, which is effectively different from either of the other two options. In this talk, we will look at the extension of the influence relation for simple games to ternary voting games (games in which the players have three voting options) and show that the influence relation orders the voters the same way as an extension of the classical Banzhaf and Shapley-Shubik indices. Also we will show that the addition of a third voting option has the effect of allowing for all asymmetric distribution of power, even ones that cannot be achieved by any simple game. (Received September 18, 2012)

1086-91-1179 **Rachel Esselstein*** (resselstein@csumb.edu), 100 Campus Center Dr, Department of Mathematics and Statistics, Seaside, CA 93955, **Jason Lee** (jleemath@gmail.com), 9800 Savage Road, Ft. Meade, MD 20755, and **Jordan White**, 100 Campus Center, Department of Mathematics and Statistics, Seaside, CA 93955. *Periodicity in 3-element Subtraction Games.* Preliminary report.

The well-known combinatorial game Nim is played with heaps of stones. Two players take turns removing stones from any heap of their choosing. Subtraction games are a generalization of nim where the number of stones a player may remove from the heap is restricted to be a number coming from a pre-specified set $S \subset \mathbb{N}$. We call S the subtraction set for the game. We retain the normal play convention, where the last player able to move wins the game.

Each subtraction set S corresponds to an infinite sequence, called the Grundy sequence, which gives information about winning strategies in any game on S .

It is not hard to show that the Grundy sequence for a subtraction game with a finite subtraction set is ultimately periodic. A more challenging problem is to describe a formula to compute the period of a Grundy sequence given any finite subtraction set S . We will present preliminary results on such methods to determine the periods for sequences on three-element subtraction sets. We will also present evidence in support of a conjecture that the period for three element subtraction sets will always be a multiple of the sum or difference of elements in the subtraction set. (Received September 23, 2012)

- 1086-91-1181 **Mark A. Krines***, Department of Mathematics, University of Iowa, 14 MacLean Hall, Iowa City, IA 52242. *Positional Procedures and the Prevalence of Inconsistent Outcomes*. Preliminary report.

It is widely accepted in social choice theory that all election procedures are flawed to some extent, whether it is due to inconsistent outcomes on subsets of alternatives, an allowance or strategic voting, or an inability for voters to cast ballots representative of their preferences. However, there are still many unanswered questions regarding the extent to which these flaws exist in election procedures. In this talk, I will discuss combinatorial results related to the prevalence of inconsistent outcomes on subsets of alternatives for positional procedures. (Received September 19, 2012)

- 1086-91-1184 **Marcus Pivato*** (marcuspivato@gmail.com), Department of Mathematics, Trent University, 1600 West Bank Drive, Peterborough, Ontario K9J 7B8, Canada, and **Klaus Nehring** (kdnehring@ucdavis.edu), Department of Economics, University of California, Davis, 1 Shields Ave, Davis, CA 95616. *The median rule in judgement aggregation*.

Let \mathcal{K} be a set of logically interdependent propositions. Suppose a group of people must form a collective view on the truth/falsehood of each element of \mathcal{K} . This is the problem of *judgement aggregation* (JA). Arrowian preference aggregation is one special case (where each element of \mathcal{K} represents a ranking of two alternatives), but JA problems also include resource allocation, committee selection, and taxonomic classification. If the voters take a majority vote for each proposition separately, then the result may be logically inconsistent. (In preference aggregation, this is the Condorcet paradox.) Thus, we need another JA mechanism.

The *median rule* chooses the logically consistent view which minimizes the average Hamming distance to the voters. (In preference aggregation, this becomes the Kemeny rule.) We axiomatically characterize the median rule as the unique JA rule which satisfies *reinforcement* (consistency under amalgamation of two subpopulations), *decomposition* (consistency under combination of two JA problems), *upper hemicontinuity* (stability under small perturbations), and *supermajority efficiency* (roughly: it is “as majoritarian as possible” while being logically consistent). (Received September 19, 2012)

- 1086-91-1205 **Andreas Darmann** and **Christian Klamler*** (christian.klamler@uni-graz.at). *Cost-sharing of continuous knapsacks*.

This paper provides a first insight into cost sharing rules for the continuous knapsack problem. Assuming a set of divisible items with weights from which a knapsack with a certain weight constraint is to be filled, different such (classes of) rules are discussed. Those - based on individual approvals of the items - optimally fill the knapsack and share the cost of the knapsack among the individuals. Using various properties of continuous knapsack cost sharing rules, we provide three characterization results. (Received September 20, 2012)

- 1086-91-1324 **Josep Freixas*** (josep.freixas@upc.edu), Escola Politècnica Superior d'Enginyeria, Av. Bases de Manresa, 61-73, 08242 Manresa, Spain, 08242 Manresa, Barcelone, Spain. *Voting games with abstention: linking completeness, weightedness and power theories*. Preliminary report.

Weighted games for several levels of approval in input and output were introduced in Freixas and Zwicker (2003). The influence relation on the set of voters for games with several levels of approval in input was introduced in Tchantcho, Difo Lambo, Pongou, and Engoulou (2008). However, there are weighted games not being complete for the influence relation, something different to what occurs for simple games. In this work we introduce several extensions of the desirability relation and from the completeness of them it follows the consistent link with weighted games, which solves the existing gap. Moreover, we show that the influence relation is consistent with a known subclass of weighted games: strongly weighted games. Power theories for ternary voting games, or games with abstention, were initiated by Felsenthal and Machover (1997). We support that these theories are consistent for complete games for the influence relation, but for other games other power theories seem to be more appropriate. (Received September 21, 2012)

- 1086-91-1472 **D. Marc Kilgour*** (mkilgour@wlu.ca), Department of Mathematics, Wilfrid Laurier University, Waterloo, Ontario N2L3C5, Canada, and **Steven J. Brams** (steven.brams@nyu.edu), Department of Politics, New York University, New York, NY 10012. *When Does Approval Voting Make the “Right Choices”?*

We assume that a voter's approval of a proposal depends on (i) the proposal's probability of being right (or good or just) and (ii) the voter's probability of making a correct judgment about its rightness (or wrongness). The state of a proposal (right or wrong), and the correctness of a voter's judgment about it, are assumed, initially, to be independent. If the average probability that voters are correct in their judgments is greater than $\frac{1}{2}$, then the proposal with the greatest probability of being right will, in expectation, receive the greatest number of

approval votes. This result also holds when voters' probabilities of being correct are state dependent but not proposal dependent; when they are functionally related in a certain way; or when voters follow a leader with an above-average probability of correctly judging proposals. Sometimes, however, voters will more frequently select the right proposal by not following a leader and, instead, making their own independent judgments (as assumed by the Condorcet Jury Theorem). Applications of these results to different kinds of voting situations are discussed. (Received September 22, 2012)

1086-91-1737 **Thomas C Ratliff*** (ratliff_thomas@wheatoncollege.edu), Wheaton College, Norton, MA 02766. *Selecting Diverse Committees with Candidates from Multiple Categories.*

When selecting committees, the voters often place priority on the overall composition of the committee in such a way that their preferences cannot be decomposed into preferences on individual candidates. This is often reflected in the voters' desire that the elected committee reflect some diversity criteria, such as gender or academic rank. One aspect that makes committee elections unwieldy is that it is impractical to ask voters for a complete ranking of all possible committees. Our approach is to ask voters for their top-ranked committee and devise voting methods that respect the diversity criteria. This talk will review previous results when the diversity criteria consists of two categories and discuss approaches when there are three or more categories. (Received September 24, 2012)

1086-91-1849 **Brian Hopkins*** (bhopskins@saintpeters.edu). *Exploring and Expanding the Robinson Goforth System for 2 by 2 Games.*

Using certain transpositions of the symmetric group S_4 , Robinson and Goforth have developed a system that connects 2 by 2 games having strict ordinal preferences. We will review and explore this structure from the perspectives of both game theory and graph theory.

Unlike previous *ad hoc* methods, Robinson and Goforth's structure connects games in a complete and consistent way. Necessarily, some adjacent games have different characteristics (e.g., the anomalous prisoner's dilemma has to have neighbors). We will consider "in-between games" to better understand such changes. These same in-between games allow the addition for some ties among the player's preferences.

Embedding their graph on a surface, the strict preference games correspond to faces; edges and vertices accommodate most games with ties. Considering the sequence of widening neighborhood sizes around a vertex partitions the graph into classes that suggest further refinements of the Robinson and Goforth structure. (Received September 24, 2012)

1086-91-1863 **Tugba Yildirim*** (tyildiri@math.fsu.edu), 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306, and **Mike Mesterton-Gibbons** (mesterto@math.fsu.edu), 202-B Love Building, 1017 Academic Way, Tallahassee, FL 32306. *Modelling musth and mate choice in an African elephant.*

The African bush or savannah elephant, *Loxodonta africana*, is a vulnerable species whose conservation requires a deeper understanding of its social behavior and structure. With this goal in mind, we are developing a suite of game-theoretic and dynamic models to explore the effects of states of musth in males and oestrus in females on mutual mate choice and contest behavior among males. This talk will describe the phenomenon of musth and other aspects of elephant social dynamics, the models we are developing to address the issues, and the progress we have made to date.

(Received September 25, 2012)

1086-91-1969 **Scott G McCalla*** (smccalla@ucla.edu), **P J Brantingham** and **M B Short**. *The effects of sacred value networks within an evolutionary, adversarial game.*

The effects of personal relationships and shared ideologies on levels of crime and the formation of criminal coalitions are studied within the context of an adversarial, evolutionary game. Here, "sacred value networks" are interpreted as connections on a graph of N players. We explore the effects on the dynamics of the system that these networks introduce, through various forms of protection from both victimization and punishment. Under local protection, these networks introduce a new fixed point within the game dynamics, which we find through a continuum approximation of the discrete game. Under more complicated, extended protection, we numerically observe the emergence of criminal coalitions, or "gangs". We also find that a high-crime steady state is much more frequent in the context of extended protection networks, in both the case of Erdős-Rényi and small world random graphs. (Received September 24, 2012)

- 1086-91-2026 **Jeffrey Nielsen*** (jeffrey.nielsen@usma.edu), 646 Swift Road, D/Math, West Point, NY 10996, and **Jessica Libertini** (jlibertini@math.uri.edu), 5 Lippitt Rd., Kingston, RI 02881. *In Search of Stable and Robust Metrics to Study Level-Specific Self-Similarity in Hierarchical Organizational Networks.*

There is interest in exploring the balance between cosmopolitan and hierarchical topography in a network as these properties can give insight into an organization's efficacy, efficiency, adaptability, and other functional attributes (Everton, 2012#). While some efforts have been made to quantify these properties at a network level, such as modularity maximization or clustering coefficients #Shakarian & Paulo, 2012#, we believe that insights can also be gained by quantifying the distribution and regularity of branching coefficients in a hierarchical network, leading us to explore level-specific self-similarity #LS3). This research explores several approaches to defining a quantifiable metric for LS3, measures the robustness and stability of these proposed metrics in pure and perturbed model networks, and uses these concepts to explore structural differences between large hierarchical organizations. (Received September 24, 2012)

- 1086-91-2270 **Ruihua Liu*** (rliu01@udayton.edu), 300 College Park, University of Dayton, Dayton, OH 45469. *Optimal Investment and Consumption Problem with Markovian Parameters.*

This presentation is concerned with an optimal investment and consumption problem for which the model parameters are driven by a continuous-time Markov chain with finite number of states representing different regimes of market. The market consists of one bond and n correlated risky assets. An investor distributes his wealth among these assets and consumes at a non-negative rate. The interest rate, the appreciation rates, the volatilities, and the utility are assumed to depend on the Markov chain. The objective is to maximize the expected discounted total utility of consumption and the expected discounted utility from terminal wealth. We solve the optimization problem by stochastic control methods for regime-switching models. Under suitable conditions, we prove a verification theorem. We apply the theorem to a class of power utility functions and obtain, up to the solution of a system of ordinary differential equations, an explicit solution of the value function and the optimal investment and consumption policies. (Received September 25, 2012)

- 1086-91-2284 **Angela G Vierling-Claassen*** (avierlin@lesley.edu), Cambridge, MA. *Gendered Division of Labor in Parenting.*

In this presentation, a game of repeated play is used to model parental child care in order to examine the gap between the expectations of egalitarian-minded couples before the transition to parenthood and the reality of parenthood with its gendered roles. The analysis shows that it is difficult to achieve the equilibrium of equal sharing of child care, even when this is the preference of the parents. This leads to a discussion of alterations and meta-strategies for couples who want to share care equally. Gender differences between parents are also modeled, including the impact these have on outcomes and equilibria. This work will be published in the journal *Rationality and Society*, and the presentation will also include a discussion of the journey from writing a mathematics paper to eventually publishing a revised form of that paper in a sociology journal. (Received September 25, 2012)

- 1086-91-2359 **Dharma Kwon** (dhkwon@illinois.edu), Champaign, IL 61820, and **Hongzhong Zhang*** (hzz244@columbia.edu), 1255 Amsterdam Ave, 928, New York, NY 10027. *Competitive Control of Market Goodwill and Strategic Exit.*

We consider the problem of two firms competing for market goodwill, which randomly evolves in time. Each firm can make irreversible investment to increase its goodwill to improve its profit stream and decrease its rival firm's goodwill. They also have an option to exit the market at any point in time. We formulate the problem as a stochastic singular control and stopping game, and we obtain a rich variety of Markov perfect equilibria. (Received September 25, 2012)

- 1086-91-2361 **G. Alex McClain*** (alex.mcclain423@gmail.com) and **Carl V. Lutzer.** *An Examination of Equilibria in the Multi-Site Iterated Prisoner's Dilemma.* Preliminary report.

Iterated Prisoner's Dilemma is a simple model for the interaction between two self-interested agents who can choose whether or not to cooperate with one another. Many real-world problems can be characterized in terms of the Iterated Prisoner's Dilemma, from the militarization of rival nations to the tradeoff between gas mileage and safety when purchasing a vehicle. The game theoretic properties of Iterated Prisoner's Dilemma are well understood, and previous research by Axelrod into the performance of various strategies in a Darwinian environment is extensive. In this paper we extend Axelrod's work by investigating the dynamics of the Iterated Prisoner's Dilemma when multiple "communities," each playing its own Iterated Prisoner's Dilemma tournament, are allowed to interact and influence each other. Specifically, we examine the case when these communities are

populated by players using two specific strategies: TIT-FOR-TAT and ALWAYS-NONCOOPERATIVE. We establish a possible range for an equilibrium in the multi-site scenario through rigorous analysis of the underlying structure of the model, and present substantial numerical data that points to the existence of such an equilibrium. (Received September 25, 2012)

1086-91-2639 **Maximiliano Liprandi*** (mliprand@ucalgary.ca), Calgary, Alberta, Canada. *Sparse spaces in the game of Blash, Slash and Dash*. Preliminary report.

The game of Blash, Slash and Dash is played on a strip of triangles, each sharing a vertex with the previous and with the next one. Here, Left and Right take turns removing an edge (a slash (/), backslash(\) or a dash(—)), along with any edges adjacent to it. As is usual with combinatorial games, the last player able to make a move is the winner. This game can be analyzed recursively with the help of two other auxiliary games - strips of triangles with dashes attached to one or both ends. Upon further inspection, one can find that the values of the game form a sparse space with a common coset, which can be used to improve the computational cost of finding new values. (Received September 25, 2012)

1086-91-2807 **Neeraj T Vijay*** (nvijay@masonlive.gmu.edu), 6 Stearrett Drive, Newark, DE 19702. *Effects of Momentum Trading on Asset Prices*.

Geometric Brownian motion is a standard model used for asset pricing. We amend this model by considering an agent-based variant that introduces market participants who try to profit from recent price trends.

Let $r(t)$ be the log-price and consider an agent i who bought the asset at time ω . Then the agent will sell when

$$|r(t) - \max_s r(s)_{\omega \leq s \leq t}| \geq d_i$$

for some threshold value $d_i > 0$. Similarly an agent j who sold the asset at time τ will change position and buy when

$$|r(t) - \min_s r(s)_{\tau \leq s \leq t}| \geq d_j.$$

When the changes in agent position are fed back into the price, cascades of buying and selling result in large and sudden price moves that are similar to those that occur in real financial markets. The model can be described as a stochastic dynamical system on the positive real line and variations of it will be used to model illiquid markets such as the housing market. (Received September 25, 2012)

92 ► *Biology and other natural sciences*

1086-92-161 **Tracy L. Stepien*** (tls52@pitt.edu), Department of Mathematics, University of Pittsburgh, 301 Thackeray Hall, Pittsburgh, PA 15260, and **David Swigon** (swigon@pitt.edu), Department of Mathematics, University of Pittsburgh, 301 Thackeray Hall, Pittsburgh, PA 15260. *Effect of stretch-dependent proliferation on collective cell migration*.

Collective cell migration plays an important role in maintaining the cohesion of epithelial cell layers and in wound healing. A recently developed mathematical model of cell layer migration based on an assumption of elastic deformation of the cell layer leads to a generalized Stefan problem. Analysis and numerical results indicate that a large class of constitutive equations for the dependence of proliferation on stretch leads to traveling wave solutions with constant wave speed. (Received July 31, 2012)

1086-92-238 **Artem Novozhilov*** (artem.novozhilov@ndsu.edu), NDSU Mathematics Dept. #2750, PO Box 6050, Fargo, ND 58108. *Analysis of a stochastic SIR model with parametric heterogeneity*. Preliminary report.

In this talk we consider a classical stochastic epidemiological model of SIR type with several types of susceptibles. In addition to the well-studied distribution of the final epidemic size, the important quantities of the probability of the major outbreak and the distribution of the length of an epidemic are studied both analytically and by means of Monte Carlo simulations. The results are compared to those of a simplest homogeneous SIR model. (Received August 11, 2012)

1086-92-316 **Weijiu Liu*** (weijiul@uca.edu), 201 Donaghey Ave, Conway, AR 72035. *Numerical Evidence for Sustaining Normal Intracellular Calcium Oscillations by Store-Operated Calcium Entry Alone in Pancreatic β -Cells*. Preliminary report.

We develop a mathematical model to numerically analyze a complex effect of depletion of intracellular calcium stores on intracellular calcium oscillations in pancreatic β -cells. When store-operated calcium entry (SOCE) is

presented and endoplasmic reticulum (ER) calcium is depleted, our numerical simulation confirmed an experimental observation that the normal calcium oscillations persist and actually are accelerated. This implies that SOCE alone can sustain the normal calcium oscillations. Also our numerical simulation showed that normal membrane potential oscillations are sustained by SOCE alone. This numerical result has not been tested yet by an experiment. When SOCE is blocked or very small, our numerical simulation confirmed other experimental observations that ER calcium can sustain normal calcium oscillations and the depletion of ER calcium transforms the normal calcium oscillations into a sustained calcium increase with oscillations of much higher frequency and much smaller amplitude, and transforms the normal membrane potential oscillations to a pattern of continuous spiking. (Received August 20, 2012)

1086-92-474 **Richard A Erickson*** (richard.erickson@ttu.edu), Box 41163, Department of Environmental Toxicology, Texas Tech University, Lubbock, TX 79407, and **Stephen B. Cox, Katharine Hayhoe, Linda J.S. Allen, Kevin R. Long and Steven M. Presley.** *Potential impact of climate change on dengue and its mosquito vector, Aedes albopictus: A mechanistic modeling approach.*

Global climate change may have profound impacts on the ecology of infectious diseases such as dengue. Traditionally, habitat envelopes and other statistical classification approaches have been used to assess climate change. These coarse approaches provide insight into species distributions and ranges, but do not provide insight into population or disease dynamics.

We examined how the transmission and maintenance dynamics of dengue were changed under projected climate conditions. A mechanistic, stage-structured population model with ordinary differential equations was used to model *Aedes albopictus*. This mosquito model was then incorporated into a disease model.

Potential changes in dengue season length were projected for three cities on the current edge of the species range: Atlanta, GA; Chicago, IL; and Lubbock, TX. High-resolution climate projections from 4 global climate models were used with projections from two emission scenarios. We found that projected climate change shortened mosquito life spans in the southern cities, which in turn may decrease the potential dengue season length. In contrast, Chicago had an increase in possible dengue season length. Our findings illustrate the difficulties in predicting how climate change may alter complex systems. (Received September 04, 2012)

1086-92-488 **L R Ritter*** (lritter@spsu.edu), 1100 S. Marietta Pkwy, Dept. of Mathematics, Marietta, GA 30060. *Foam cell formation in atherosclerosis: HDL and macrophage reverse cholesterol transport.* Preliminary report.

Macrophage derived foam cells are a major constituent of the fatty deposits characterizing the disease atherosclerosis. Foam cells are formed when certain immune cells (macrophages) take on oxidized low density lipoproteins through failed phagocytosis. High density lipoproteins (HDL) are known to have a number of anti-atherogenic effects. One of these stems from their ability to remove excess cellular cholesterol for processing in the liver—a process called reverse cholesterol transport (RCT). HDL perform macrophage RCT by binding to forming foam cells and removing excess lipids by efflux transporters.

We consider a model of foam cell formation accounting for macrophage RCT. The model takes the form of a system of ordinary differential equations. Numerical and steady state analyses are performed; the results are interpreted in terms of their potential bio-medical implications. (Received September 04, 2012)

1086-92-507 **Lih-Ing W Roeger*** (lih-ing.roeger@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, and **Sze-Bi Hsu.** *A diamond food web model with one predator two preys and one nutrient resource.* Preliminary report.

We consider a model for a planktonic ecosystem in which two prey species compete for one nutrient resource, and are preyed upon by the same predator. The model exhibits the mixing of both the exploitative and the apparent competitions. We show that under certain conditions, the one species equilibrium is globally stable by constructing a suitable Lyapunov function. (Received September 05, 2012)

1086-92-732 **John W Cain*** (jcain2@richmond.edu), University of Richmond, Dept. of Mathematics and Computer Science, 28 Westhampton Way, Richmond, VA 23173. *Chaos Control in Cardiac Tissue: Local Stimulation Versus Far-Field Pacing.* Preliminary report.

We contrast the modeling and simulation of two vastly different methods for terminating cardiac arrhythmias. The traditional method, local stimulation, is used by medical devices such as the implantable cardioverter-defibrillator (ICD). An ICD delivers spatially-localized electrical stimuli via an implanted electrode, often at the

base of the right ventricle. The newer method, known as far-field pacing (FFP), involves application of a pulsed electric field across the whole heart. If the FFP field strength is sufficiently large, propagating electrical waves can emanate from interfaces between conducting and non-conducting tissue, ideally leading to a “resetting” of the tissue in which a normal rhythm resumes. Experiments indicate that FFP is highly successful in this regard, even at energies far lower than the pain-inducing jolts of local stimulation.

Our simulations, performed using a standard reaction-diffusion PDE model of waves in excitable media, support a previously-reported and very natural suspicion: Attempts to use impulsive forcing to control spatiotemporal chaos will fail if the forcing is restricted to an overly-localized region. We discuss possible implications in the realm of medical device design, as well as other contexts outside of medicine. (Received September 11, 2012)

1086-92-849 **Timothy C Reluga***, Department of Mathematics, Penn State University, University Park, PA 16802, and **Allison K. Shaw**. *Dynamical-systems insights into migration*. Preliminary report.

Long-distance migrations form some of the most astonishing phenomena in animal life on planet earth, and also some of the clearest examples of oscillations in populations. There are many different examples of long-distance migration for very different animals, including monarchs annual migration to Mexico, wildebeest migration in Africa, and salmon migrations up fresh-water rivers. It's clear that these species gain advantages in survival based on their migration patterns. But it's less clear how species without human capacities for reasoning, evolved to exhibit these long-distance migrations. In this talk, I'll present some recent and classical dynamical-systems results the explore how migratory behavior can emerge. (Received September 14, 2012)

1086-92-869 **Victor Barranca*** (barrav@rpi.edu), 2187 12th Street, Troy, NY 12180. *Is our Sensing Compressed?*

Along the early stages of many sensory pathways, significant downstream reductions occur in the numbers of neurons transmitting stimuli. To understand how much information is lost due to such a reduction, we investigate an idealized mathematical model of the retina using an integrate-and-fire type modeling structure. Our model features a large network of receptor cells randomly and sparsely coupled to a relatively small network of downstream neurons. Using numerical simulations of our model dynamical system combined with a static mean-field analytical reduction, we demonstrate firing patterns in the downstream neurons can in fact be used to reconstruct stimuli. We study how the quality of the reconstruction depends on our choice physiological features reflected by the model parameters, and confirm mechanisms of data-preservation similar to compressive sensing may be at work in receptive fields. We expect our methods to provide guidance for studying information loss in more realistic neuronal network models as well as experiments studying stimuli reconstruction in sensory pathways. (Received September 14, 2012)

1086-92-965 **Suzanne Lenhart*** (lenhart@math.utk.edu), U of Tennessee, Math Dept, Knoxville, TN 37996, and **Kelly Sturner**. *Using Probability and Limits to Investigate Biodiversity*.

Probability can used to derive Simpson's index of biodiversity and then limits can used to investigate the effects of varying species 'evenness' and 'richness'. Using these ideas in middle school, high school, or beginning undergraduate classes will be discussed together with appropriate Common Core Standards. (Received September 17, 2012)

1086-92-1005 **Nakeya D Williams*** (ndwilli5@ncsu.edu), Raleigh, NC 27695, and **Mette S Olufsen, Hien Tran** and **Jesper Mehlsen**. *An Optimal Control Approach for Modeling the Response to Head-Up Tilt*. Preliminary report.

Short term cardiovascular responses to head-up tilt (HUT) experiments involve complex cardiovascular regulation in order to maintain blood pressure at homeostatic levels. This poster presents an optimal control approach to modeling effects of cardiovascular regulation due to HUT on efferents including heart rate, cardiac contractility, vascular resistance, and vessel compliance. The model consists of a five-compartment lumped parameter model, a physiologically based sub-model that describes gravitational effects during HUT, and finally a cardiovascular regulation model that adjusts those efferents mentioned. (Received September 17, 2012)

1086-92-1155 **Xiaoyang Dong*** (xiaoyang.dong@mavs.uta.edu), Department of Mathematics, University of Texas at Arlington, P.O. Box 19408, Arlington, TX 76019, and **Hristo Kojouharov** and **James Grover**. *Mathematical Models of Nutrient Recycling and Toxin Production in a Gradostat*.

We discuss several gradostat models in which a microbial population excretes a biochemical that can get recycled back into the system as a nutrient source. Each mathematical model consists of six ordinary differential

equations and represents the dynamics of harmful algal blooms in lakes with fringing coves. We examine three different situations of biochemical production which is based on the algal growth rate, mortality, and nutrient concentration, respectively. Local and global stability analysis of the equilibria predicts that algal abundance and biochemical concentration can be both washed out or persistent under different environmental conditions. All theoretical results are supported by a set of numerical simulations. (Received September 19, 2012)

1086-92-1197 **Eugene R. Wahl*** (eugene.r.wahl@noaa.gov), 325 Broadway Street, Code E/CC23, Boulder, CO 80305. *Advances and Opportunities for Mathematical Treatment of Paleoclimate Reconstructions.*

Important advances in the field of paleoclimate reconstruction have recently come from the interaction of climatologists and mathematicians. For example, consideration of random processes naturally involved in using properties of one earth subsystem ("proxies") to deduce properties of another (climate) motivates the re-evaluation of reconstruction methods in terms of joint or conditional probability distributions. In this regard, application of Bayesian Hierarchical Modeling (BHM) allows for: 1) explicit characterization of data and climate processes in the reconstruction model; 2) better representation of spatial characteristics in reconstruction design; and 3) systematic representation of uncertainties, leading to probabilistic ensemble outcomes. Traditional "transfer functions" often can be described in terms of BHMs, allowing for formal comparison and treatment of methods in new ways. In parallel, there is significant re-exploration of calibration/validation theory and bootstrapping, targeting a deeper understanding of the potential and limits of traditional methods and their extension into true ensembles. Examples of these and other advances will be presented, with the goal of stimulating further collaboration between scientists and mathematicians in paleoclimatology. (Received September 20, 2012)

1086-92-1253 **Alan Hastings*** (amhastings@ucdavis.edu), Department of Environmental Science & Policy, University of California, One Shields Avenue, Davis, CA 95616. *Role of time scales in the response of ecological populations to time varying resources.*

Temporally and spatially varying resource levels are key features of ecological systems. Simple models based on delay equations incorporating the key features of temporally varying resources and specific descriptions of survivorship for consumer species show the overriding importance of the time dependence of available resources and the role that subsidies play in allowing species to persist. Persistence of species with lifetimes short relative to the timescale of resource variability is determined by the geometric mean of resource levels, while the persistence of species where resources vary on a much shorter time scale (or with exponential survivorship) are determined by the arithmetic mean of resource levels. Models incorporating both time-varying resources and explicit life histories dramatically change our understanding of how fluctuations in resource availability through time and space will affect population persistence and community dynamics. (Received September 20, 2012)

1086-92-1295 **Terrance J. Quinn*** (terry.quinn@alaska.edu), Juneau, AK 99801. *Features of biologically realistic fishery models frequently used in fish stock assessment.*

A fisheries stock assessment model is a model of the population dynamics of a harvested fish species that integrates information from the fishery with scientifically collected biological and survey data. At a minimum, there needs to be a historical dataset comprised of total removals, age or size information, and a relative index of population abundance. Model parameters include cohort abundance, natural and fishing mortality, and calibration coefficients. A realistic model contains those biological and human factors that play a major role in population dynamics. Current models currently provide for realistic changes in cohort abundance and fishing mortality over time. Some fishery models have thousands of observations and hundreds of parameters, and a variety of software has been developed to meet the demand for efficient and accurate parameter estimation. Recent advances to increase biological realism include: (1) allowing for stochasticity in early life survival to recruitment, (2) including temporal variations in natural mortality, either through covariates (such as disease and environment) or explicit incorporation of multi-species interactions (such as predator-prey), and (3) reconciling and exposing data conflicts among multiple datasets. (Received September 20, 2012)

1086-92-1365 **Christopher Strickland*** (strickla@math.colostate.edu), 101 Weber Building, Colorado State University, Fort Collins, CO 80523, and **Gerhard Dangelmayr** and **Patrick Shipman**. *Modeling the nonlocal dispersal of invasive plant species in heterogeneous landscapes.*

Mathematical models for the spread of biological organisms typically utilize population growth and dispersal dynamics in an attempt to predict an expected value of the population distribution at some point in the future. These models often ignore uncertainty in initial conditions, neglect ecological heterogeneity in the landscape, and even misrepresent the underlying stochastic growth and dispersal processes they are supposed to represent.

Assuming the underlying population dynamics of an invasive plant can be described by a nonlinear, stochastic contact birth process, we develop a deterministic model for the probability of species presence as a function of time and space. While assuming no information about the relative size of the current population, our model focuses on the goal of species presence prediction resulting in a model that naturally incorporates heterogeneity in the landscape as well as uncertainty in initial conditions. (Received September 21, 2012)

1086-92-1381 **Carrie Diaz Eaton*** (ceaton@unity.edu), ceaton@unity.edu. *The Evolution of Ecological Communities.*

Networks are of current interest in many fields from informatics to economics and ecology. In particular, the building of networks over time and their emergent properties is of interest. Mathematical theory has been developed to explain the formation of various link distributions and connectivity patterns in standard networks. However, current models of ecological networks, in particular, have focused on replicating the observed patterns while neglecting the ongoing evolutionary and ecological dynamics. I discuss a variation on preferential attachment theory incorporates evolutionary and ecological dynamics to explain the formation of some ecological networks, called mutualistic webs. I also discuss why the history of interactions between community members are important in determining the emergent structure of networks. (Received September 24, 2012)

1086-92-1387 **Yingyun Shen*** (yshen@math.fsu.edu), FSU Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306, and **Mike Mesterton-Gibbons.** *Use of Lifespan-Shortening Wolbachia to Control Dengue Fever: Demographic Factors.*

Dengue fever is currently a serious arthropod-borne disease, affecting around 50 million people worldwide every year. There is no vaccine, and none of the current prevention methods can effectively reduce its transmission.

Dengue fever requires a relatively long extrinsic incubation period in its mosquito vector *Aedes aegypti* before transmission to a new human host, so the life expectation of infectious vectors strongly influences the spread of the disease. The bacterium *Wolbachia* greatly shortens the lifespan of *A. aegypti*. My current research focuses on a new SEIR model that explores the effect of *Wolbachia* on humans, using numerical solutions to investigate demographic factors that influence basic reproductive number and equilibrium prevalence. The persistence of the dengue fever sensitively depends on the mosquito survival profile. We studied the relationship among the number of *Wolbachia*-infected mosquitoes, the mosquito mortality rate, and the number of infectious humans at equilibrium. We found that the disease can be eliminated under certain circumstances. A stochastic model for transmission of dengue fever is also built to explore the above demographic factors. (Received September 25, 2012)

1086-92-1419 **David K Hammond*** (hammond@uoregon.edu), NeuroInformatics Center, 5294 University of Oregon, Eugene, OR 97403. *Estimating cortical activity from EEG by spatiotemporal regularization exploiting anatomical connectivity and signal propagation delay.* Preliminary report.

Electroencephalography (EEG) data consist of voltages on the scalp surface generated by cortical current activity inside the brain. Estimating these cortical currents is a highly underdetermined inverse problem, and generally requires imposing some regularization by assuming prior knowledge about the cortical activity. A crucial property of the human brain is the pattern in which different cortical areas are connected to each other. Recent developments in diffusion weighted MRI imaging allow the non-invasive measurement of the white matter fibers forming these connections, enabling construction of a weighted graph representing brain connectivity. We describe using this so-called cortical connectome to construct a fully spatiotemporal regularization functional for source estimation of time-series EEG. This procedure involves lifting the spatial connectome graph to a spatiotemporal graph, with edges added in a manner modeling signal delays due to finite axonal propagation velocity. Regularization is given by penalizing sums of squares of differences across the spatiotemporal edges. We study solving the resulting variational problem by conjugate gradients, and compare against a related purely spatial approach which does not exploit temporal regularity. (Received September 21, 2012)

1086-92-1442 **Shantia Yarahmadian*** (syarahmadian@math.msstate.edu), Department of Mathematics and Statistics, Allen Hall 410, Mississippi State, MS 39762. *Trichotomous Markov Noise and Dynamic instability of microtubules in three states.* Preliminary report.

Microtubules are intercellular filaments. Throughout the phenomenon of undergoing stochastic growth and shrinkage, they act as a molecular machine. This phenomenon is called dynamic instability. We will study the dynamic instability of microtubules in three states of growth, pause and shrinkage through Trichotomous Markov Noise (TMN). The analytic expression of Green's functions and first passage time distribution are calculated. (Received September 24, 2012)

- 1086-92-1444 **Jiang Jiang** (jjiang@nimbios.org), NIMBioS, 1122 Volunteer Blvd., Suite 106, University of Tennessee, Knoxville, TN 37996-3410, **Daozhou Gao**, 513 Parnassus Ave, Medical Science, San Francisco, CA 94143, and **Donald L. DeAngelis*** (ddeangelis@bio.miami.edu), 1301 Memorial Drive, P. O. Box 249118, Coral Gables, FL 33124. *Mathematical Analysis of Ecotone Resilience*.

The ecotone between two different vegetation types, salinity-tolerant and salinity-intolerant, is modeled along a gradual gradient of groundwater salinity from highly saline at the coast to lower salinity values inland. We studied a model for the two vegetation types and soil salinity using bifurcation analysis. As a result of the feedbacks, a range of groundwater salinities exist, bounded by two bifurcation points, over which two alternative equilibria exist, one with only salinity-tolerant vegetation and one with only salinity-intolerant vegetation. This range was shown to be sensitive to parameters of rate of upward infiltration of salinity from groundwater into the soil. Increasing diffusion rates of vegetation leads to shrinkage of the range between the bifurcation points. The spatial pattern of vegetation caused by these interactions is a sharp ecotone between salt-tolerant vegetation (mangroves) near the coastline and salt-intolerant vegetation inland, although the underlying elevation and groundwater salinity decreases only gradually inland along the ecotone. A disturbance such as an input of salinity to the soil from a storm surge could upset this stable boundary, leading to a regime shift of salinity-tolerant vegetation inland. (Received September 22, 2012)

- 1086-92-1452 **Bret D Elder**, **Brian Rehill**, **Kyle Haynes** and **Greg Dwyer*** (gdwyer@uchicago.edu), 1101 E 57th Street, Dept of Ecology and Evolution, University of Chicago, Chicago, IL 60615. *Host-pathogen interactions, induced plant defenses, and insect outbreaks*. Preliminary report.

Outbreaks of defoliating insects damage forests and exacerbate climate change, but ecologists continue to debate whether outbreaks are driven by natural enemies, such as pathogens and predators, or by plant defenses that are induced by defoliation. Outbreaks of the gypsy moth (*Lymantria dispar*) are terminated by epidemics of a fatal virus disease, whereas the direct effects of induced defenses are weak. Gypsy moth cycles are therefore widely believed to be driven by the virus, but because the virus is transmitted during larval feeding, induced tree defenses may alter virus transmission rates. We use a field experiment to show that induced hydrolyzable tannins strongly reduce variability in infection risk among gypsy-moth larvae, and by modifying a natural-enemy model to allow for induced defenses, we show that this effect makes outbreaks more likely. Only some of the tree species that gypsy moths feed on have induced defenses, however, but by extending the model to allow for spatial variability in inducibility, we show that induced defenses can explain a sub-harmonic in time series of gypsy moth outbreaks. (Received September 22, 2012)

- 1086-92-1471 **Jim M Cushing*** (cushing@math.arizona.edu), Department of Mathematics, 617 N Santa Rita Av, University of Arizona, Tucson, AZ 85721, and **Jarred T. Hudson**. *A basic model for the evolutionarily adaptive dynamics of a population subject to a strong Allee effect*.

Population dynamic models that incorporate nonlinear density effects on fitness typically assume deleterious effects due to increased population numbers or density. This negative feedback feature (as exemplified by the famous logistic equation) was overwhelmingly the assumption built into models for population and ecological dynamics during the last century and, for the most part, remains so today. During the last decade there has been an upsurge in interest in positive density (Allee) effects that can occur at low population densities. This interest has been motivated primarily by conservation issues and concerns about the extinction of endangered species. A "strong" Allee effect is one that results in a threshold below which a population will (deterministically) go extinct. In this talk I consider a basic, prototype ODE model for a strong Allee effect when placed in an evolutionary setting, so as to model a population able to adapt evolutionarily. I'll give a complete analysis of the global asymptotic dynamics of the model. I'll also give some toy examples designed to illustrate the results and to draw some ecological punch lines about the interplay between Allee effects and evolutionary adaptation. (Received September 22, 2012)

- 1086-92-1514 **Justin R. Dunmyre***, dunmyre@umich.edu, and **Victoria Booth**. *Coupled Flip-flops: Noise and Analysis for a Sleep-wake Cycle Model*.

Transitions between the wake state and REM and non-REM sleep states may be governed by a regulatory network composed of coupled flip-flops. One flip-flop network controls sleep-wake transitions while the REM-nonREM cycle is controlled by a separate flip-flop. We analyze the effects of different sources of noise on a single flip-flop network focusing on changes in state durations. This analysis provides insights regarding the interaction dynamics of coupled flip-flops subject to physiological variability. (Received September 23, 2012)

- 1086-92-1604 **Marco V Martinez*** (mmarti52@utk.edu) and **Suzanne Lenhart**. *Optimal control of integrodifference equations in a host-pathogen system*. Preliminary report.

The gypsy moth is an invasive species and a destructive forest defoliator in North America. This work focuses on optimal control techniques for models of areas where the population is in the invasion front. Integrodifference equations incorporate space into a system of discrete time equations. We design an objective functional to minimize the cost generated by the defoliation caused by the gypsy moth and the cost of controlling the population. Existence and uniqueness results for the optimal control and corresponding states have been completed. We use a forward backward sweep numerical method, and our numerical results suggest spatial and temporal location and intensity of optimal controls. (Received September 23, 2012)

- 1086-92-1641 **Tilahun A Muche*** (muchet@savannahstate.edu), Savannah State University, Engineering Technology and Mathematics Dept., 3219 College Street, Savannah, GA, 31404, Savannah, GA 31404. *Hamiltonian sets of polygonal paths in a 4-valent spatial graphs*. Preliminary report.

Graphs with 4 valent rigid vertices and two end points are called simple assembly graphs. The *assembly number* of Γ , denoted by $An(\Gamma)$, is defined by $An(\Gamma) = \min\{k | \text{there exists a Hamiltonian set of polygonal paths } \{\gamma_1, \dots, \gamma_k\} \text{ in } \Gamma\}$ where polygonal paths are paths that take "90° turn" at each vertex. For a positive integer n , we define *minimal realization number for n* to be $R_{min}(n) = \min\{|\Gamma| : An(\Gamma) = n\}$, where $|\Gamma|$ is the number of 4-valent vertices in Γ . For a positive integer n , a graph Γ such that $R_{min}(n) = |\Gamma|$ is called *minimal realization graph*. We denote by $\mathcal{R}_{min}(n)$, the set of minimal realization graphs for some positive integer n . Each $\Gamma \in \mathcal{R}_{min}(n)$ has the property that $|\Gamma| \leq 3n - 2$ and $R_{min}(n) < R_{min}(n + 1)$ for every natural number n . The assembly graph $\hat{\Gamma}^0$ obtained from a given assembly graph Γ by substituting every edge with a loop, is called *loop-saturated graph*. We prove that loop saturated assembly graphs achieve the bound of $3n - 2$ and if a simple assembly graph Γ with $An(\Gamma) = k$ has no loops then it is not in $\mathcal{R}_{min}(k)$. (Received September 23, 2012)

- 1086-92-1753 **Holly V Moeller*** (hollyvm@stanford.edu) and **Michael G Neubert**. *Optimal investment in a multi-mutualist system: Trees and ectomycorrhizal fungi*.

Many tree species form mutualistic partnerships with a group of belowground fungi known as ectomycorrhizae. The maintenance of these partnerships depends upon tree payments of photosynthetically fixed carbon to the fungi. In return, the fungi provide nutrients, water, and pathogen defense services to the host tree. Interestingly, an individual tree may host dozens of species of ectomycorrhizae simultaneously, including fungi which appear to be less beneficial than other community members at that time.

Empirical evidence suggests that some of this diversity may be explained by niche differences among fungi, with some species better able than others to access particular nutrient pools, provide pathogen defense, and so on. Here, we examine the importance of temporal variation to the maintenance of fungal diversity. In particular, we ask whether a tree that experiences environmental variation might "bet hedge," by investing in a suite of fungi more diverse than its present environmental settings dictate because future conditions might require ready access to other partners. (Received September 24, 2012)

- 1086-92-1770 **Georgiy P Karev*** (karev@ncbi.nlm.nih.gov), 3014 Homewood Pkwy, Kensington, MD 20895. *Non-exponential models of dynamics of biological communities and the Principle of minimal of Tsallis information gain*. Preliminary report.

In order to model prebiological evolution, Varga and Szathmary (1997), Szathmary (2006) proposed a model of a community composed of sub-exponential (parabolic) population growth, described by the multi-dimensional non-linear system of ODEs. I show that this complex model can be reduced to a single ODE and then effectively solved. The current distribution of the individuals in the community provides minimum of the Tsallis information gain under appropriate constraint. Important informal corollaries may follow from the fundamental property of the Tsallis entropy being non-additive for independent subsystems. For sub-exponential systems, the information about two exhaustive independent subsystems is not enough to obtain the information about the whole system. Hence, the general methodological principle, reductionism, may not work for such systems.

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- 1086-92-1794 **Stephan B Munch*** (steve.munch@noaa.gov), **Ethan Deyle**, **Charles Perretti** and **George Sugihara**. *Towards model-free ecosystem management*. Preliminary report.

There are many good reasons for ecosystem-based approaches to management. In particular, ecosystem approaches to management promise to make explicit the trade-offs between yields at different trophic levels and help avoid the systemic problems engendered by single-species management. Numerous ecosystem models have

been developed to help quantify these trade-offs. There is, however, a great gulf between ecosystem models and ecological reality. In light of this, the key to successful ecosystem-based management may be to make robust, short-term ecosystem forecasts that don't rely on an explicit model structure. To this end, we have developed tools for non-parametric analysis of population dynamics. These methods significantly outperform parametric models at multispecies forecasting for both simulated data and field observations. Current research in this area is focused on scaling-up these nonparametric methods to ecosystem-wide forecasts and the development of robust harvest policies. (Received September 24, 2012)

1086-92-1937 **J. Che*** (jche@gnf.org), **Z. Guo** (zguo@gnf.org), **B. Li** (bli@math.ucsd.edu), **L. Cheng** (lcheng@math.ucsd.edu) and **J. Dzubiella** (jdzubiel@physik.hu-berlin.de). *Hydration Free Energy from a Variational Implicit Solvent Model.*

Hydration free energy is an important properties for organic and bio molecules involved in drug discovery industry. Explicit water simulations are usually too time consuming for daily industrial applications, and conventional implicit solvent models lack the self-consistency between polar and non-polar interactions. Recently, we developed a variational implicit solvent model (VISM) that treats polar and non-polar interactions self-consistently. Here, we applied it to a large set of diverse small organic molecules as well as protein complexes, and demonstrate its capability to accurately reproduce the hydration free energy with far fewer adjustable parameters. In addition to providing more accurate physical insights into the solvation process, the efficiency of the numerical implementation through level set equations allows the calculations to be of practical use in industrial settings. (Received September 24, 2012)

1086-92-1977 **Ben R. Morin**, **Eli Fenichel** and **Carlos Castillo-Chavez*** (ccchavez@asu.edu), MCMSC, Arizona State University, PO Box 871904, Tempe, AZ 85287-1904. *Disease Dynamics with Behavioral Driven Contact Transmission Rates.*

The recent influenza pandemic (A/H1N1, 2009) brought back the importance that human decisions (behavior) play on the day-to-day interactions of individuals in a community. Social contacts are formulated macroscopically within a susceptible-infectious-recovered or SIR epidemiological framework via state-dependent non-linear incidence rates. We apply unpublished theoretical results by S.P. Blythe, the late K. Cooke and Castillo-Chavez (SB-KC-CC) to the study of the impact of individuals' adaptive responses to epidemics that take into account epidemiological and economic factors. The resulting generalized SIR framework supports multiple equilibria and oscillatory epidemiological dynamics (as noted by SB-KC-CC) and its analysis facilitates the study of disease dynamics as a complex adaptive system. We dedicate this talk and the manuscript submitted to NRM to Kenneth Cooke who passed away on August 25, 2007 at the age of 82. (Received September 24, 2012)

1086-92-1979 **M. J. Garlick***, martha.garlick@sdsmt.edu, and **J. A. Powell**, **M. B. Hooten** and **L. R. McFarlane**. *A spatial model for chronic wasting disease in mule deer.*

Chronic wasting disease (CWD) is an infectious prion disease, which is rare in the free-ranging deer population of Utah. We present a sex-structured, spatial model for the spread of CWD over heterogeneous landscapes, incorporating both horizontal and environmental transmission pathways. To connect the local movement of deer to the regional spread of CWD, we use ecological diffusion with motility coefficients estimated from mule deer movement data. Female and male deer are modeled separately to reflect behavioral differences that are thought to affect disease transmission. A homogenization technique is applied to greatly reduce the computational load for a simulation of disease spread across a portion of Southeast Utah. The homogenized model provides accuracy while maintaining fidelity to small-scale habitat effects on deer distribution, including differential aggregation in land cover types with high residence times. We use the averaged coefficients from the homogenized model to explore asymptotic invasion speed and critical population size for portions of our study area. We find that incorporating deer movement through heterogeneous environments with disease spread is critical in predicting how CWD spreads from one area to another. (Received September 24, 2012)

1086-92-1989 **Lisa Rogers*** (lrogers@cims.nyu.edu), 251 Mercer Street, New York, NY 10012. *A Mathematical Model of the Sleep/Wake Regulatory System.* Preliminary report.

The mammalian sleep/wake system is governed by several interacting populations of neurons in and around the hypothalamus. We present here a model of a minimal system of the sleep and wake promoting neuron populations in the ventrolateral preoptic nucleus (VLPO), basal forebrain (BF), parabrachial nucleus/precoeruleus area (PB/PC) and lateral hypothalamus (LH). The model is formed using leaky Integrate and Fire firing dynamics for electrical input and chemical kinetics of receptor-neurotransmitter/neuromodulator interaction to quantify chemical synaptic input. We also present a novel but simple way of relating firing rates of neuron populations to corresponding concentrations of neurotransmitter/neuromodulator, allowing us to track both electrical and

chemical output. Rate and equilibrium constants are obtained using appropriate mammalian data from the BRENDA enzyme database. (Received September 24, 2012)

1086-92-2018 **Glenn Ledder*** (gledder@math.unl.edu). *Using freeze and thaw data for lakes to study global warming.*

Global warming does not necessarily mean an increase in global temperature. Just as the heating of a cup of ice water serves primarily to melt the ice rather than raise the temperature, the most significant effect of global warming is its effect on the earth's ice cover. Data for total ice cover is hard to obtain, but other data sets can be used for the same purpose. The National Snow and Ice Data Center maintains a web-accessible repository of historical data on freeze dates, thaw dates, and total duration of ice cover for many lakes throughout the earth; indeed, freeze and thaw reports for some lakes date back almost two hundred years. This mass of data contains patterns that are obscured by the large effect of random annual variation. Nevertheless, linear regression can be used to detect long-term trends. In this talk, we introduce the NSIDC data and show how it can be used with a simple spreadsheet to find these long-term trends and assess the evidence for global warming. (Received September 24, 2012)

1086-92-2031 **Dori Luli*** (dori.luli@asu.edu) and **Sharon M Crook**. *Dynamics of a Conductance-based Neuronal Network Model of Olfaction in Drosophila.*

The olfactory system of *Drosophila* is a favorable system for investigating the basic principles of neural coding. Olfactory receptor neurons (ORNs) detect odors and send signals to the antennal lobe (AL), where odors are represented by spatiotemporal patterns of activity that are similar across individuals. However, the exact network connectivity and the contributions of the different neuron types to AL dynamics are still to be determined. Here, we develop minimal but realistic conductance-based models for AL neurons. Each cell is represented by a system of ODEs, where channel kinetics are based on experimental data. We examine the mathematical structure of these neuron models, which include cell types that exhibit repetitive firing and bursting. We then develop a neuronal network model of the AL, where ORN input is modeled with Poisson processes, and network connections mimic chemical synapses and gap junctions as described in the literature. We investigate possible connectivity patterns with the aim of proposing interactions within the AL that account for the variety of activity patterns observed in experimental data for different odors. Computational studies are used to understand odor response profiles for different cell types and their contributions to network dynamics. (Received September 24, 2012)

1086-92-2056 **Matthew Cattivera***, mcattivera@sandiego.edu, **Seth Haney**, shaney@sandiego.edu, and **Adam Siepielski**, adamsiepielski@sandiego.edu. *Stochastic Effects on the Outcome of Species in Competition.* Preliminary report.

The vast biological diversity of the Earth cannot be overstated, however, the mechanisms that promote this diversity are still hotly debated. It is well known in community ecology that stochasticity can change the fate of a system of competing species. For example, systems that lead to coexistence in deterministic models may result in competitive exclusion in a stochastic model. Here we study a system of competing species with both stochastic and deterministic models to evaluate the impact of environmental variation and stochastic effects on coexistence. Using a deterministic model we can obtain analytical solutions in the autonomous case and use a perturbation method to extend this to approximate solutions where environmental variation is present. We compare this to a discrete stochastic model and find that, while the stochastic model predicts competitive exclusion, no such environmental variation can reproduce this behavior in the deterministic case. (Received September 24, 2012)

1086-92-2076 **Brianna G. Payne*** (brpayne@ucollege.edu), 3800 South 48th Street, Jorgenson Hall 317A, Lincoln, NE 68506, **Shandelle M. Henson** (henson@andrews.edu), Berrien Springs, MI 49104-0350, **James L. Hayward** (hayward@andrews.edu), Berrien Springs, MI 49104-0410, **Libby C. Megna**, Berrien Springs, MI 49104-0410, and **Susana R. Velastegui Chavez**, Santa Domingo, Ecuador. *Temporal Dynamics of Galapagos Marine Iguana (*Amblyrhynchus cristatus*) haulout.* Preliminary report.

Galápagos Marine Iguanas (*Amblyrhynchus cristatus*) briefly forage in marine habitats but spend their remaining time hauled out on land. A wide range of diurnal activities, from social and thermoregulatory behaviors to sleep and food processing, occurs during haulout. To understand the dynamics of haulout and foraging in relation to environmental factors, we fit compartmental models derived from ordinary differential equations to field data from two sites on Cabo Douglas Isla Fernandina. The best haulout model accounts for 77–80% of observed variability at one site and includes the environmental variables solar elevation, heat index, tide height, and relative humidity. Using only the predictable variables solar elevation and tide height, the model still accounts for 72% of system variability. Although the environmental variables that predict haulout are not identical

across sites, the methodology employed is a vital tool for parsing out otherwise unclear relationships between organisms and their environments. In the face of global change, the employment of these investigative tools from mathematics could positively impact conservation measures developed for this endemic species. (Received September 24, 2012)

1086-92-2098 **Alison Margolskee*** (amargol@ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695, and **James Selgrade** (selgrade@math.ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695. *A Dynamical Model for the Human Menstrual Cycle that Simulates the Key Hormonal Changes of the Menopausal Transition.*

A system of 16 nonlinear differential equations and 66 parameters is developed to model the hormonal regulation of the female reproductive cycle applying to women from age 20 through 51. The model simulates the declining pool of primordial follicles and resulting decrease in antimüllerian hormone (AMH) and follicular phase inhibin B (InhB), and increase in follicular phase follicle stimulating hormone (FSH). These hormone changes are markers of declining ovarian function and can be attributed to the diminishing pool of the primordial follicles. (Received September 24, 2012)

1086-92-2146 **Alexis Sparko*** (asparko@smith.edu), Box 9039, Smith College, Northampton, MA 01063, and **Yu Jin**. *Ducking Responsibility: How Laziness Pays Off in Arctic Duck Populations.* Preliminary report.

The producer-scrourer behavior is a type of exploitative foraging strategy commonly adopted when food sources are scarce and patchy. The producers in a group will independently search for food while the scrourers exploit these efforts and follow the producers to food sources. Motivated specifically by the producer/scrourer habits of arctic Eider ducks, we create a differential equation model of this behavior. We then use this model to explore long term patterns of population size based on various environmental factors such as food availability, food patch size, and travel time between patches. (Received September 24, 2012)

1086-92-2241 **Shalla Hanson*** (shanson@smith.edu), Box 8952, Smith College, Northampton, MA 01063, and **Kelly Zaccheo**. *Modeling Zebrafish Spinal Cord Development.* Preliminary report.

Mitosis or cell division during nervous system development must be tightly regulated. In this project, we collaborated with a developmental biologist (M. Barresi, Smith College) in developing a mathematical model of the neural tube (spinal cord) development in zebra fish. Specifically, we look at the population of radial glial cells, a type of neuronal stem cells. The wild-type/normal cell line is compared with a mutant Kif11 cell line. Kif11 is a crucial protein that is essential in pulling cells apart during mitosis, thus Kif11 mutation would result in complete a mitotic arrest. We develop ordinary differential equation models of the cell division process and perform data fitting to match experimental data. We investigate the role of apoptosis (cell death) as well as other indirect feedback which affect the population of dividing radial glial cell. (Received September 25, 2012)

1086-92-2252 **David Gamble Sykes*** (dgsykes@uncg.edu) and **Jan Rychtar**. *Cost-Benefit Analysis of Kleptoparasitic Interactions.* Preliminary report.

A kleptoparasitic interaction occurs when one individual (a kleptoparasite) attempts to take resources from another individual. Some animals exhibit different behavior in similar interactions, and we would like to understand why they may have evolved to do so. Internal states, such as health, age, or hunger, can affect what behavioral strategies yield optimal gains. To study this effect, we have created a mathematical model that describes the outcomes of these interactions in terms of the value of contested resources, the cost of a fight (or a similar conflict), and the internal states of individuals involved. Changing the degree to which internal states affect an individual's appraisal of resources changes optimal behavior, as indicated by our model. When this degree is high, it can happen that individuals should forgo stealing from weaker individuals, and this does not happen when the degree is low. This degree can also be set so that the constant strategy of always stealing is optimal behavior; however, for most parameter settings, optimal behavior is not a constant strategy (i.e. a strategy of always making the same decision). Optimal behavior should, in most cases, be adaptive to changes in resource value, cost of conflict and internal health. (Received September 25, 2012)

1086-92-2341 **Abra Brisbin*** (abrisbin@gmail.com), **Liewei Wang** and **Brooke Fridley**. *Model choice for gene pathway-based priors in Bayesian association studies.*

Gene pathways encode a wealth of information that could be used to improve power in genetic association studies. For example, researchers may wish to utilize the prior belief that more closely connected genes have more correlated effects on the trait. In this work, we compare Bayesian models for encoding network structure,

by placing priors on either the covariance matrix or the inverse covariance matrix (CAR models) of gene effects. We also compare two approaches for choosing a model, DIC and detection rate, and find that these approaches frequently support different models. (Received September 25, 2012)

1086-92-2373 **Urmi Ghosh-Dastidar*** (ughosh-dastidar@citytech.cuny.edu), Namm 711, 300 Jay St, Brooklyn, NY 11201, and **Suzanne Lenhart** (lenhart@math.utk.edu), 1122 Volunteer Blvd., Suite 106, University of Tennessee, Knoxville, TN 37996. *Study and Analysis of Aquatic Pathogenic Transmission.*

Cholera is a diarrhoeal disease that is caused by an intestinal bacteria named as *Vibrio cholerae*. Recently an outbreak of cholera in Haiti brought public attention on this deadly disease. Cholera outbreak is not common in a developed country; however, handling this outbreak still remains a major challenge in both developing and underdeveloped country once the disease has its first onset. In this work, the objective in our differential equation model is to find an effective optimal vaccination strategy to minimize the disease related mortality and to reduce the associated costs. The effect of seasonality in pathogen transmission on vaccination strategies was investigated under several types of disease scenarios, including an endemic case and a new outbreak case. This model is an extension of a general water-borne pathogen model. This work involves optimal control problem formulation, analysis and numerical simulations. (Received September 25, 2012)

1086-92-2412 **Kamuela E Yong***, kamuela.yong@asu.edu, and **Anuj Mubayi** and **Christopher Kribs-Zaleta**. *Estimating biting rates of Trypanosoma cruzi infected triatomine vector species on preferred sylvatic hosts in Texas.*

The parasite *Trypanosoma cruzi*, spread by triatomine vectors, affects over 100 mammalian species throughout the Americas, including humans, in whom it causes Chagas' disease. In the U.S., only a few cases have been documented of human infection by vectors, but prevalence is high in sylvatic hosts (primarily raccoons in the southeast and woodrats in Texas). The sylvatic transmission of *T. cruzi* is spread by the vector species *Triatoma sanguisuga* and *Triatoma gerstaeckeri* biting their preferred hosts and thus creating multiple interacting vector-hosts cycles. The goal of this study is to quantify the number of contacts between different host and vector species in Texas from an agent-based model framework. The contact rates, which represent bites, are required to estimate transmission coefficients, which can be applied to models of infection dynamics. (Received September 25, 2012)

1086-92-2423 **Sebastian J Schreiber*** (sschreiber@ucdavis.edu), **Jay Rosenheim**, **Lawrence Harder** and **Neal Williams**. *Pollen limitation in plants: Ecological and evolutionary perspectives.*

Sexual reproduction in plants often requires the transfer of pollen between flowers by environmental currents or pollinators (e.g., mainly insects, but birds, bats and other assorted species). When plants receive too little pollen, they may experience reductions in seed production and are considered pollen-limited. This limitation is a basic metric for assessing plants' sensitivity to environmental change like recent global declines in pollinators. To date, however, the frequency of pollen limitation as well as the evolutionary and ecological causes of pollen limited is debated. To provide new perspective on these issues, we use stochastic models to examine (i) how uncertainty of pollen availability simultaneously influences the evolution of reproductive allocations to attracting pollen, producing ovules, and provisioning for seeds, and (ii) the ecological consequences of these allocation strategies to seed production following sudden shifts in pollen availability or resource availability. (Received September 25, 2012)

1086-92-2447 **Majid Bani-Yaghoub***, UMKC Department of Mathematics and Statistics, 5100 Rockhill Road, Kansas City, MO 64110. *Modeling and analysis of intermittently shed pathogens capable of environmental persistence.* Preliminary report.

A system of ordinary differential equations is constructed to investigate the evolutionary ecology of pathogen intermittent shedding and the environmental persistence of free-living pathogen. Specifically, by considering various tradeoffs between intermittent shedding and environmental persistence, we show that the overall transmissibility fitness of several infectious agents can be optimized (presumably) through evolution. The stability analysis of the disease-free and endemic equilibria indicates that such optimization can be responsible for several disease outbreaks around the world. Using the data related to *E. coli* O157:H7 transmission in a cattle-environment system, the impacts of such tradeoffs on the disease dynamics is numerically examined. (Received September 25, 2012)

- 1086-92-2462 **Evelyn Kamaria Thomas*** (evelyn.k.thomas@gmail.com), **Katharine Gurski** and **Kathleen Hoffman**. *Analysis of SI Models with Multiple Interacting Populations Using Subpopulations with Forcing Terms*.

As a system of differential equations describing an epidemiological system becomes large with multiple connections between subpopulations, the expressions for reproductive numbers and endemic equilibria become algebraically complicated which makes drawing conclusions based on biological parameters difficult. We present a new method which deconstructs the larger system into smaller subsystems, captures the bridges between the smaller systems as external forces, and bounds the reproductive numbers of the full system in terms of reproductive numbers of the smaller systems, which are algebraically tractable. This method also allows us to analyze the size and stability of the endemic equilibria. (Received September 25, 2012)

- 1086-92-2479 **Kathryn J Montovan*** (kjs237@cornell.edu), NY, and **Laura E Jones, Saskya van Nouhuys** and **Hudson Kern Reeve**. *Evolutionary pressures maintain consistently low parasitism rates in the parasitoid wasp *Hyposoter horticola**. Preliminary report.

We present five evolutionary hypotheses for the benefit of low parasitism rates for *Hyposoter horticola* using game theory models, field data, and spatial simulation models to determine the validity of each hypotheses and the implications of spatial structure on the evolution of optimal parasitism rates. We study this question in the context of a well-characterized interaction between a parasitoid wasp and host butterfly on a fragmented landscape. We show the extent to which landscape features (patch quality, density, and connectedness) and host attributes (dispersal ability, reproductive success, mortality) affect the optimal parasitism rate; thus unveiling the role of spatial processes in the interaction. (Received September 25, 2012)

- 1086-92-2483 **Jonathan J Sarhad*** (jonathan.sarhad@ucr.edu), **Robert C Carlson** and **Kurt E Anderson**. *Population Persistence In River Networks Using Quantum Graphs*.

Aquatic organisms contend with downstream biased flow in a complex tree-like domain. Differential equation models are often used to study population persistence by considering the dependence of persistence on such variables as advection rate, dispersal characteristics, and domain size. Classical differential equation models rely on interval domains to facilitate analysis while other models that explicitly consider network geometry discretize river habitat into distinct patches. We use a reaction-diffusion-advection equation in a quantum tree graph to identify when a single population will grow at low density, by doing a principal eigenvalue analysis in terms of domain scaling parameters and advection speeds. Our analytical and numerical studies show that network geometry has a significant impact on persistence. This presentation will discuss model definition, basic properties of solutions, and persistence results, while placing emphasis on numerical results. In particular, numerical results show that domain volume alone is a poor indicator of persistence and that interval models can underestimate or overestimate persistence relative to tree models, depending on advection speed. (Received September 25, 2012)

- 1086-92-2530 **Courtney L Davis*** (courtney.davis2@pepperdine.edu), **Rezwanul Wahid, Franklin R Toapanta, Marcelo B Szein** and **Doron Levy**. *Applying Mathematical Tools to Accelerate *Shigella* Vaccine Development*.

We establish a mathematical framework for studying immune interactions with *Shigella*, a dysentery-causing bacteria that kills over one million people worldwide each year. The long-term goal of this approach is to inform *Shigella* vaccine design by elucidating which immune components and bacterial targets are crucial for establishing *Shigella* immunity. Our delay differential equation model focuses on antibody and B cell responses directed against antigens like LPS in *Shigella*'s outer membrane. We find that antibody-based vaccines targeting only surface antigens cannot elicit sufficient immunity for protection. Additional boosting prior to infection would require a four-orders-of-magnitude increase in antibodies to sufficiently prevent epithelial invasion. However, boosting anti-LPS B memory can confer protection, which suggests these cells may correlate with immunity. An extension of the model reveals that targeting both LPS and epithelial entry proteins is a promising avenue to advance vaccine development. This work introduces mathematical models to the *Shigella* vaccine development effort and lays a foundation for joint theoretical/experimental/clinical approaches to *Shigella* vaccine design. (Received September 25, 2012)

- 1086-92-2596 **Lauren M. Taylor*** (taylo21m@dukes.jmu.edu) and **Jennifer E. Roth** (roth2je@dukes.jmu.edu). *Optimal Strategies for Arrival and Departure of Male *Onthophagus taurus**. Preliminary report.

Onthophagus taurus is a species of dung beetle that displays a characteristic male dimorphism in the presence or absence of horns. Major males (with horns) exhibit a defensive mating strategy, while minor males (without horns) exhibit a sneaking mating strategy. Since dung pads are suitable for use during a short time interval,

arrival and departure times are key in determining reproductive success. Using a simplified probability model, we mathematically analyzed dispersal strategies to determine an optimal strategy. (Received September 25, 2012)

1086-92-2612 **Patrick Gaskill***, 1015 Floyd Ave, Richmond, VA 23284, and **Rebecca Heise, Ramana Pidaparti** and **Angela Reynolds**. *Agent-based modeling of strain-induced lung inflammation*.

Mechanical ventilation is needed in aged patients whose respiratory systems fail to achieve adequate gas exchange function. Despite its necessity, mechanical ventilation gives rise to strain in the lung tissue which then recruits an inflammatory response. In order to decrease ventilator-induced inflammation, we are developing an age-dependent multi-scale computational model. The initial state of model development is the creation of an agent-based model for strain-induced inflammatory response in lung tissue. We have implemented rules that govern the dynamics between lung tissue cells, bacteria, immune cells, and inflammatory mediators. We then computed the likelihood of various biological outcomes, e.g. infection, strain-induced inflammation, and health for different strain and infection scenarios. (Received September 25, 2012)

1086-92-2671 **Jonathan R. Bates*** (jbates@math.fsu.edu), FSU Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306-4510. *Use of the heat kernel to establish natural maps between anatomical surface models*.

We study anatomical variation using surface models (compact, closed surfaces in Euclidean space). A difficult problem in computational anatomy is the unsupervised construction of a diffeomorphism between two surfaces that matches points in a biologically meaningful way. One approach has been to use the heat kernel associated with each surface to derive correspondences between points, thought of as a stochastic affinity between them. We discuss a family of mappings from a surface into Euclidean space related to the heat kernel and an interpretation of Euclidean distance between points in the images. Understanding the relationship between these mappings, the heat kernel, and geodesic distance is important if we are to make guarantees regarding the use of these tools in computational anatomy for constructing a “natural” diffeomorphism between surfaces. (Received September 25, 2012)

1086-92-2676 **Theodore E. Galanthay*** (theodore.galanthay@colorado.edu). *Evolutionary stability of movement strategies in a two-patch habitat selection model*. Preliminary report.

How do movement costs affect the dynamic and evolutionary stability of movement strategies? We consider a simple two-patch ecosystem model in which species’ growth is governed by the logistic equation, and species move between patches by using various movement strategies. We assume that species differ only in their movement strategies. We allow the strategies to change on a time scale slower than the population dynamics and ask how many species can coexist in the system. We analyze this coupled non-linear ordinary differential equation model to determine not only the ecological stability of the populations but also the evolutionary stability of the strategies. We compare how the incorporation of two different types of costs affects the original analysis. To accomplish this, we use ideas from evolutionary game theory and dynamical systems. (Received September 25, 2012)

1086-92-2782 **Selenne H. Garcia - Torres*** (garciato@usc.edu), 2321 W Repetto Ave, Montebello, CA 90640. *Structured Two-Stage Population Model with Migration*. Preliminary report.

A structured population is one where there are consistent differences among the members of the population as a function of some attribute such as age, size, or physiological condition as they develop. Here we partition the population by reproductive maturity. We take two such populations of the same species in somewhat adjacent locations and consider migration between the two locations. When constant breeding and migration is considered we propose simple conditions under which the model has a unique periodic state that is globally attractive with respect to the first quadrant. These conditions are much simpler than those given by other authors. Results and further work for more than two locations and periodic cases will be discussed. (Received September 25, 2012)

1086-92-2799 **Catherine King*** (cking@email.wm.edu) and **Kate Shipman**. *Accurately Modeling Zooplankton Mortality Rates*. Preliminary report.

Modeling zooplankton dynamics properly is increasing in importance because zooplankton grazing has been shown to impact critical issues ranging from eutrophication to climate change. Zooplankton mortality rates are the most critical aspect of the currently existing models; however, current models only include linear predatory mortality rates. This incomplete approach underestimates zooplankton mortality and therefore overestimates actual zooplankton abundances. In order to further determine the significance of the zooplankton mortality term, we performed both sensitivity and interval analysis on the currently existing model. These methods analyzed the

changes in the eigenvalues and eigenvectors as the parameters were altered. Similarly, new techniques in interval analysis were used to determine the maximum epsilon, or error, allowed for a certain parameter that will still allow growth in the population. Analyzing the mortality term in this way will help us create more efficient and accurate models. Non-linear mortality terms that separate non-predatory and predatory mortality rates were also included. Correctly incorporating both predatory and non-predatory mortality terms will improve current models for aquatic ecosystems around the world. (Received September 25, 2012)

1086-92-2814 **Nikolay Strigul*** (nick.strigul@vancouver.wsu.edu), 14204 NE Salmon Creek Avenue, Vancouver, WA 98686, and **Ionut Florescu**. *A Markov chain model for the forest stand dynamics.*

The forested ecosystem is a complex adaptive system having a complicated hierarchical structure. The Matreshka model considers vegetation dynamics as the results of vegetation processes at several hierarchical scales driven by natural and anthropogenic disturbances of different magnitude. The particular processes include growth of individual trees, dynamics of trees within the stand, forest stand mosaic, and changes of the collection of forest stands of different forest types at the landscape level. In this presentation we introduce a Markov chain model of forest stand dynamics. The model is an irreducible Markov chain containing transition probabilities as estimated using the US and Canadian data sets. We have obtained various macroscopic characteristics of forest stands from USDA FIA data on individual trees (biodiversity measures, uniformity of forest stand composition, biomass and basal area measures, and an original parameter called the shade tolerance index). We have also described the spatial patterns of the forest stand mosaic of North-American forests. It is anticipated that this research will improve our understanding of the role of spatial heterogeneity caused by disturbances of different magnitude on successional patterns of forested ecosystems. (Received September 25, 2012)

1086-92-2834 **Theresa Marie Dalmut*** (dalmuttm@dukes.jmu.edu) and **Emily Cate** (cateeb@dukes.jmu.edu). *Modeling Fitness of *Onthophagus taurus*: The Effects of Density on Mating Success.*

Male *Onthophagus taurus* dung beetles have a characteristic dimorphism that leads to differing reproductive strategies. Horned major males exhibit a guarding strategy while unhorned minor males exhibit a sneaking strategy. The success of these strategies depends on the number of other males with which an individual competes. We developed random models using Matlab and NetLogo to explore the density dependence of reproductive success. Our models showed that the sneaking strategy for minors was advantageous under lower density conditions, suggesting that the guarding strategy for majors requires high densities. (Received September 25, 2012)

1086-92-2863 **Joseph Juliano*** (joseph.juliano@asu.edu), **Andrea Hawkins-Daarud**, **Russ Rockne**, **Peter Canoll** and **Kristin Swanson**. *A multi-scale approach to investigate invasion characteristics of heterogeneous glial cells and its implications on the overall growth kinetics of glioma progression.* Preliminary report.

A rat model for glioblastoma multi-form (GBM), the most malignant and common form of brain cancer, has recently been developed by depositing a platelet derived growth factor (PDGF) expressing retrovirus into a rat brain. The retrovirally-infected cells recruit healthy surrounding glial cells inducing a malignant phenotype similar to human GBM. These studies have led to the development of the Proliferation-Invasion-Recruitment (PIR) mathematical model, a system of PDEs used to investigate the contribution of recruitment via PDGF secretion to the overall dynamics of glioblastomas. This continuous model is based primarily on parameters of net rates of proliferation and invasion. In previous work, these parameters were estimated at a global level from serial magnetic resonance imaging. In this research, we connect estimates of invasion in a multi-scale approach by estimating fitted mean-squared-distances of individually tracked cell movement to a persistent random walk model. Individual cell estimates and population estimates were used to determine appropriate invasion parameters for the PIR model. The quality of these estimates is quantified by using them in the PIR model and making comparisons between predicted population distribution and observed tumor kinetics. (Received September 25, 2012)

1086-92-2887 **Easton R. White*** (easton.white@asu.edu) and **John D. Nagy**. *A Stochastic, Spatially-Structured Model for Metapopulation Dynamics with Applications to the American Pika (*Ochotona princeps*).*

Conventionally, population biologists have tended to focus on deterministic properties of population dynamics, like equilibrium population sizes, minimum viable populations and cyclic population dynamics. Recently, however, there has been a shift toward incorporating stochastic processes into population models. Stochastic

phenomena are likely to drive metapopulations. Here we report on a newly developed computational model designed to evaluate the significance of random fluctuations in general metapopulations. The model is formulated as a birth-death stochastic process on a finite, spatially explicit array of patches. As a test of the model, we apply it to the best-known mammalian metapopulation in North America: the American pika (*Ochotona princeps*) population living on the ore dumps in the ghost mining town of Bodie, California. The model is able to produce the mean population size seen at Bodie but only generates 20 percent of the variance evident in the actual data. Therefore we predict that a considerable amount of the variance must be driven by environmental stochasticity. Similar patterns of demographic stochasticity, having little effect on inter-annual population fluctuations, have emerged in other terrestrial studies of vertebrates. (Received September 26, 2012)

1086-92-2969 **Jiehua Zhu***, Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA 30458, and **Xiezhong Li**, Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA 30458. *A generalized l_1 greedy algorithm for image reconstruction in computed tomography.*

The sparse vector solutions for an underdetermined system of linear equations $Ax = b$ have many applications in signal recovery and image reconstruction in tomography. Under certain conditions, the sparsest solution can be found by solving a constrained l_1 minimization problem: $\min \|x\|_1$ subject to $Ax = b$. Recently, the reweighted l_1 minimization and l_1 greedy algorithm have been introduced to improve the convergence of the l_1 minimization problem. As an extension, a generalized l_1 greedy algorithm for computerized tomography (CT) is proposed in this paper. It is implemented as a generalized total variation minimization for images with sparse gradients in CT. A numerical experiment is also given to illustrate the advantage of the new algorithm. (Received September 26, 2012)

1086-92-2984 **Piotr Slomka*** (piotr.slomka@cshs.org), Dept. of Imaging, Cedars-Sinai Medical Center, 8700 Beverly Blvd., Los Angeles, CA 90048. *Computational image analysis methods for modern cardiac imaging data.*

Cardiac imaging is an indispensable tool in detecting and monitoring coronary heart disease. Computed Tomography (CT), Magnetic Resonance Imaging (MRI), nuclear imaging (PET and SPECT), and hybrid techniques can produce large amounts of data. Such anatomical images can be combined with additional physiologic data, overlaying detailed physiological information about the heart both in 3D and 4D. Cardiac imaging technologies present physicians with unprecedented amounts of data and make it difficult to perform accurate visual analysis. Recent automated techniques in nuclear cardiology imaging have shown promise to outperform even experienced clinicians in detecting the disease. Therefore new computational paradigms have to significantly enhance the value of these complex medical tests. We aim to review various software approaches applied to analysis of cardiac data for the following computational problems: 3D & 4D segmentation of the heart, automatic extraction of coronary vessels, automatic detection of lesions likely to cause a heart attack, detection and correction of 3D physiological patient and organ motion during high-resolution scans, and optimal diagnosis by a combination of several imaging features and additional patient information by machine learning methods. (Received September 26, 2012)

1086-92-2988 **Barry Merriman*** (barrym@ucla.edu), Life Technologies, Inc., 3175 Staley Road, Grand Island, NY 14072. *The Future of Math in Biology: Solving Disease, Creating Life.* Preliminary report.

I will summarize the state of technology in reading "DNA Genome Sequencing" and in writing "DNA synthetic biology" and describe the roles that math can play, both inside the core technologies, as well as in the major applications to hunting genes that cause disease, and creating artificial life forms with desired properties. (Received September 27, 2012)

93 ► *Systems theory; control*

1086-93-157 **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, 303 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803-4918. *Control and Robustness Analysis for Curve Tracking with Unknown Control Gains.*

The adaptive control and parameter identification problem in robotic curve tracking involves designing a nonlinear controller that identifies the unknown model parameter and ensures that the robot moves parallel to, but a fixed positive distance from, the given curve. We show how this problem can be solved using a strict Lyapunov function. Our method makes it possible to prove robust tracking with respect to additive uncertainty on the

control in terms of input-to-state stability, under a bound on the disturbance that maintains forward invariance of a class of invariant polygons. This work is joint with Fumin Zhang from Georgia Tech. (Received July 30, 2012)

1086-93-288 **Dimplekumar N Chalishajar*** (dipu17370@yahoo.com), 417 Mallory Hall, Dept. of Applied Mathematics, Lexington, VA 24450. *Controllability of Second order Neutral Functional Differential Inclusion with Infinite Delay-A Theoretical and a Numerical Approach.*

In this short article we have studied the sufficient condition for the exact controllability of second order neutral functional differential inclusion with infinite delay and impulsive terms using the techniques of functional analysis and monotone operator theory. We claim that the phase space considered by different authors are not correct. We have defined a new notion of phase space to prove the control result. An example is provided to illustrate the theory. Then we have used an abstract numerical technique to get the numerical aspect of the same problem which justifies theory also. (Received August 15, 2012)

1086-93-603 **M. Najafi**, Department of Mathematics, Kent State University, Ashtabula, OH, and **Mohammad Moe Najafi*** (mnajafi1@kent.edu), Department of Physics, Kent, OH 44242. *Stabilizability of Coupling Controllers of Waves due to Energy functional and Decomposition methods.*

In this paper, the stabilizability conditions of a system of wave equations, coupled in parallel with distributed springs and viscous dampers, are investigated via energy perturbation and decomposition methods for different wave propagation speeds. To this end, the mathematical analysis of Eigen spectrums of vibration, energy multipliers, energy perturbation, etc. was employed. The analytical solution of this system in \mathbb{R}^n , $n \leq 3$, whose energy will be damped out by the distributed internal velocity feedback controllers, was also under consideration to support the theoretical aspect of this research (Received September 08, 2012)

1086-93-1364 **Gangaram S Ladde*** (gladde@usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 East Fowler Avenue, CMC 342, Tampa, FL 33620-5700. *Network Dynamic Process under Stochastic Perturbations.* Preliminary report.

By developing a network dynamic model under random perturbations, the qualitative and quantitative properties are investigated. A single node network dynamic model is presented to illustrate the role and the scope of study. (Received September 21, 2012)

1086-93-1466 **Jacqueline Marie Yanchuck*** (yan6374@setonhill.edu), 105 Bent Tree Drive, Lancaster, PA 17603, and **Caleb Marc Brown, Camila Eugenia Reyes, Eric Eager** and **Alan Veliz-Cuba**. *The Effect of Experiment Design on Network Inference.* Preliminary report.

The network inference or reverse engineering problem consists on estimating the connectivity of a system from data. This problem is an important aspect of many areas of applied mathematics, specially when modeling biological systems. Recently, algorithms to reverse engineer Boolean network models have been developed; however, methods for collecting the data sets have not been examined sufficiently and it is not known what is the best way to collect data in order to obtain the best inferred network. In this talk, we show that for Boolean networks there are optimal ways to collect data for the network inference problem, based on the number of nodes in the network and the amount of data that is available. The results of our work provide a basis for researchers to obtain the most efficient data set, depending on experimental circumstances, to perform network inference. (Received September 22, 2012)

1086-93-2280 **Stanley R Huddy*** (huddysr@clarkson.edu), 8 Clarkson Avenue, Box: 5815, Potsdam, NY 13699, and **Joseph D Skufca** (jskufca@clarkson.edu), 8 Clarkson Avenue, Box 5815, Potsdam, NY 13699. *Amplitude Death Solutions for Stabilization of DC Microgrids with Instantaneous Constant-Power Loads.*

Constant-power loads on dc micro-grids create a destabilizing effect on the circuit that can lead to severe voltage and frequency oscillations. Amplitude death is a coupling induced stabilization of the fixed point of a dynamical system. This paper applies amplitude death methods to the stabilization problem in this constant-power setting. The amplitude death methods provide an open loop control solution to stabilize the system. Two methods - one using delay, the other using circuit heterogeneity are examined. Each method is demonstrated through numerical simulations.

(Received September 25, 2012)

94 ► *Information and communication, circuits*

1086-94-1294 **Ido Tal** (ital@mail.ucsd.edu), 9500 Gilman Dr, La Jolla, CA 92093, and **Alexander Vardy*** (avardy@ucsd.edu), 9500 Gilman Dr, La Jolla, CA 92093. *On list decoding of polar codes.*

The discovery of polar codes is widely regarded as one of the major breakthroughs in coding theory in the past decade. These codes provably achieve the capacity of any discrete memoryless symmetric channel, with low encoding and decoding complexity. However, it has been observed empirically that polar codes do not perform as well as, say, turbo codes or LDPC codes at short and moderate code lengths. Thus a key problem in the theory of polar codes is that of improving their performance at such length. We observe that significant gains can be attained using a list-decoding algorithm for polar codes along with a subtle modification of the code structure. The algorithm retains the desirable properties of the conventional decoder, such as low complexity and recursive implementation. In practice, simulations on the binary-input Gaussian channel (and other channels) show that, already at length 1024, list decoding of polar codes can outperform the best-known LDPC codes. In theory, list decoding of polar codes raises many challenging open problems. (Received September 20, 2012)

1086-94-2970 **Joseph D Lakey*** (jlakey@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003-8001, and **Jeffrey A Hogan** (jeff.hogan@newcastle.edu.au), School of Mathematics and Physical Sciences, University of Newcastle, Callaghan, NSW 2308, Australia. *Recent Progress in Duration and Bandwidth Limiting.*

The mathematical theory of time and band limiting was developed in the 1960s by H. Landau, D. Slepian and H.O. Pollak in a series of papers in the Bell System Technical Journal. Recent progress since 2000 deals largely with numerical issues and approximations of functions that are essentially limited to a time interval and a union of frequency intervals. This talk will address these matters, and connections to sampling of multiband signals. (Received September 26, 2012)

97 ► *Mathematics education*

1086-97-145 **Sue Geller*** (geller@math.tamu.edu). *Research for Beginning Mathematics Students.* Preliminary report.

There is a myth that students need to have a lot of math to do research. This is false. For the last five summers there has been a Pre-REU for students who have at least two semesters of calculus. This is one part of Texas A&M's Mentoring through Critical Transition Points program as part of an NSF grant. In this part students learn about signal and image processing and work in groups, first to work through a loosely guided project, and then to expand it to their own work. This talk will contain a discussion of the results, both mathematical and educational, including the effect on the students as they progressed through their education and went to graduate school or work. (Received July 28, 2012)

1086-97-167 **James J Madden*** (madden@math.lsu.edu), Dept. Math., LSU, Baton Rouge, LA 70803, and **Frank Neubrandner** (neubrand@math.lsu.edu), Dept. Math., LSU, Baton Rouge, LA 70803. *The Louisiana Math and Science Teacher Community.* Preliminary report.

The Louisiana State University Master of Natural Sciences degree (MNS) is administered by LSU Graduate School the LSU College of Science. It provides the depth and breadth of study in the sciences that is required of science professionals. With major support from NSF, USDoE and other sources, the LSU MNS has become a hub in the Louisiana Math and Science Teacher Professional Community, acting as an exchange for ideas and practices, providing access to mathematical and scientific knowledge in forms that are useful to teachers and supporting a culture that seeks and employs empirical evidence to deal with the problems of STEM education. In this talk, we will address several questions related to the MNS degree program and the community of K-12 teachers and university faculty that has grown around it. How were grant funds used to build the community? What are the benefits to K-12 mathematics education and what evidence supports claims of benefit? What challenges does the MNS face in sustaining the professional community in the future? We pay particular attention to reporting what we have found out about how mathematical knowledge must be engineered and packaged in a graduate degree program if it is to serve the professional community of mathematics teachers. (Received August 01, 2012)

- 1086-97-326 **Elizabeth A. Burroughs*** (burroughs@math.montana.edu), Department of Mathematical Sciences, 2-214 Wilson Hall, Bozeman, MT 59717. *Mathematics Classroom Coaching in Grades K-8.*

Classroom coaching is an on-site professional development model based on a partnership between a teacher and a classroom coach and focused on research-based instructional strategies and mathematics content. Its ultimate goal is improved student learning in mathematics. Examining Mathematics Coaching (EMC) is a research project studying the types and depth of knowledge held by effective mathematics classroom coaches. EMC researchers have been working with mathematics coaches and teachers in grades K-8 classrooms for over three years. This talk will describe what makes a knowledgeable coach, elements of professional development for coaches that is focused on standards-based mathematics, and opportunities for mathematicians to engage in mathematics classrooms through coaching. (Received August 21, 2012)

- 1086-97-340 **Richard S Millman***, CEISMC, 760 Spring St, NW, #102, Atlanta, GA 30308, and **Daniel Connelly** and **Cher Hendricks**. *A Course of Proofs and Higher-level Abstract mathematics for High Achieving High School Students*. Preliminary report.

The goals of the course are to develop a mathematical habit of the mind, to work individually and in teams to solve mathematical problems, and to be prepared for higher-level abstract mathematics courses. Our approaches are to help students construct valid proofs (sometimes motivated by examples), identify the fallacious reasoning of incorrect proofs, and to apply mathematical rigor to problem solving. The course was taught to 10 high school students (after 19 the previous one) all of whom have had at least three semesters of calculus, in a charter school in a large metro area. Specific areas include number theory, its application to cryptography, and the non-silo approach to mathematics. A description of the course and the two years that it was taught will be described. Analysis of feedback from the students will be presented. (Received August 22, 2012)

- 1086-97-401 **Mary Ann Nelson*** (mnelso15@gmu.edu), George Mason University, 4400 University Drive, Mail Stop 3F2, Fairfax, VA 22030. *Improving Understanding, Grades and Retention: Oral Reviews.*

Calculus is often considered the gatekeeper to STEM majors. Unfortunately, nationally about 40% of Calculus I students fail. This paper will report on a study designed to improve students' pass rates, understanding and retention in calculus. The study was framed in a constructivist view of learning with formative oral reviews as the primary intervention. Voluntary, ungraded orals took place prior to each written exam in groups of about five students. Emphasis was on multiple representations, multiple solution strategies, sense-making, mathematical connections and mathematical discourse. Data was collected for four years for fall Calculus I and spring Calculus II students. In at least five of the six unit exams each year, students participating in orals did significantly better (6-20% better on average) than the non-participants, and participants' final course grades averaged .6 to 1 letter grade higher. These improvements were seen across all ability groups. We will present measures of motivation that show that motivation alone does not account for students' dramatic improvements, and present data that demonstrates an average drop in Calculus I failure rates from 31 to 23%, and Calculus II drops from 26 to 20%. Orals have now been piloted by five other Universities. (Received August 29, 2012)

- 1086-97-449 **Michael Nakamaye*** (nakamaye@math.unm.edu). *Opportunities for mathematicians to work with K-12 teachers.*

Over the past decade I have had many opportunities to be involved in the professional development of elementary, middle school, and high school teachers. These include

- a.: teaching university courses for future teachers,
- b.: teaching with Intel Math,
- c.: working on a state funded MSP program,
- d.: running a local Math Teachers' Circle,
- e.: writing tasks (and helping others to write tasks) for Illustrative Mathematics.

I would like to share with others some of what I have learned (and ways in which I have grown) from these different endeavors. With so many different ways to contribute, there is a good place for all mathematicians who wish to learn more about K-12 education. Like every other important endeavor, success is not easy to find or quantify but the rewards of becoming involved are very tangible. (Received September 02, 2012)

- 1086-97-813 **Michael Mays*** (mays@math.wvu.edu), Department of Mathematics WVU, Morgantown, WV 26506-6310, and **W. Gary Martin** (wgarymartin@me.com), Auburn University, Auburn, AL 36849. *The Mathematics Teacher Education Partnership.*

The Mathematics Teacher Education Partnership (MTE-Partnership), an initiative of the Science and Mathematics Teacher Imperative of the Association of Public and Land-grant Universities, is a partnership of institutions of higher education and K-12 schools, districts, and other organizations working collaboratively to redesign secondary mathematics teacher preparation programs.

Its goal is to transform the preparation of secondary mathematics teachers to ensure teacher candidates can promote mathematical excellence in their future students, leading to college and career readiness as described in the Common Core State Standards for Mathematics (CCSS-M) and other documents.

MTE-Partnership has developed a set of guiding principles describing a shared vision to be explored and refined by the MTE-Partnership and others involved in preparing secondary mathematics teachers. The guiding principles are separated into three sections focusing on partnerships that undergird secondary mathematics teacher preparation, the knowledge and skills that secondary mathematics teacher candidates should develop, and the support structures that are necessary for successful programs. (Received September 13, 2012)

- 1086-97-818 **John T Baldwin*** (jbaldwin@uic.edu), MSCS UIC M/C 249, 851 S. Morgan, Chicago, IL 60607, and **Andreas N Mueller**. *Geometry, the Common core, and Proof.* Preliminary report.

We will report on a workshop to be held on alternate Saturdays in the Fall of 2012 with Chicago High School Mathematics Teachers. This workshop will try to integrate a careful presentation of synthetic geometry (modeled on Euclid) with the transformational approach highlighted in the Common Core Standards. This series of workshops will study synthetic (axiomatic) geometry motivated by a concrete problem and with careful attention to motivating the axioms and definitions. We will start with the problem of dividing a line into n equal parts. Seeing that an easy construction for this task actually does what it says will take the entire workshop and require all the basic properties of congruence and parallelism. We will connect the transformational approach of the Common Core with the justification of axioms, especially congruence axioms. Participants will reflect on how these ideas interact with the Common Core standards and with their current teaching practice. (Received September 13, 2012)

- 1086-97-881 **Laurie O. Cavey*** (lauriecavey@boisestate.edu), 1910 University Drive, Mathematics Department/MG 235, Boise, ID 83725-1555, and **U. Kaiser** and **M. Kinzel**. *Developing a Course to Address Mathematical Knowledge for Teaching Functions and Modeling.* Preliminary report.

As a member of the MTE-P, we are currently taking steps to improve mathematics content preparation of our secondary mathematics teacher candidates. During this presentation we will share information about the development of a course on functions and modeling for prospective secondary mathematics teachers and plans for assessment. A mathematician, two mathematics teacher educators, and a high school teacher are collaborating on this effort. This work is part of a first-step in critically examining and revising our secondary mathematics teacher preparation program in light of the Common Core State Standards in Mathematics. Course design principles and an outline of topics will be shared as well as an initial draft of an instrument we are developing to measure teachers' mathematical knowledge of functions. We will also report on an initial pilot of the instrument planned for the end of the fall 2012 semester. (Received September 14, 2012)

- 1086-97-882 **John A. Velling*** (jvelling@brooklyn.cuny.edu), 2900 Bedford Avenue, Brooklyn, NY 11210. *Online Mathematics Pedagogy: MathLynx.* Preliminary report.

MathLynx is the first dynamically generated interactive pedagogy environment. It is purely web-based, relying on multiple open-source softwares: MathJax for presentation of LaTeX, jsxGraph for 2-d graphics, three.js for 3-d graphics, a customized MathDox formula editor for client mathematical entry, all communicating with a server-side Sage engine. With such an array of tools, we have created a cross-linked library of mathematical topics for gateway level courses, incorporating many of the features of other interactive texts, and extending well beyond them.

Here we will present a tour of the library, including special features available for instructors and institutions. We will briefly discuss how it has been used and student reactions. (Received September 14, 2012)

1086-97-1063 **Lila F Roberts*** (lilaroberts@clayton.edu), 2000 Clayton State Blvd, Clayton State University, Morrow, GA 30260. *Interactive Mathematics in your Hand.*

Electronic materials for hand-held devices (tablets, smartphones, e-readers and the like) have potential to provide students a traveling mobile bookshelf, making it possible for learning to occur 24/7. Pushing static content to these powerful devices seems a waste of an opportunity when the devices are capable of so much more. This presentation will focus on widgets that provide interactive mathematics in iBooks. Several examples will be presented that make use of MathJax, JSXGraph, and other technologies for building interactivity. A brief demonstration of embedding interactive widgets into iBooks Author will be provided. Ability to extend interactive content to non-Apple devices will be explored. (Received September 18, 2012)

1086-97-1142 **Galyna Dobrovol'ska*** (dobrovol@math.uchicago.edu). *Fourier-Malgrange transform and Kronecker coefficients.* Preliminary report.

I will derive a result of Brion on Kronecker coefficients from a computation of Fourier-Malgrange transform of some local systems on projective space corresponding to representations of the symmetric group. I will also indicate an elementary proof of this result of Brion. (Received September 19, 2012)

1086-97-1146 **Esther R Widiasih*** (ewidiasih@math.arizona.edu), 617 N Santa Rita, Mathematics, University of Arizona, Tucson, AZ 85721. *Conceptual Earth's Climate Models: Opportunities in Mathematics Classrooms.* Preliminary report.

Earth's climate is a fascinating system both in the physical sense and, even more, in the mathematical sense. When viewed as a dynamical system, Earth's climate consists of multiple scales in time and space having various oscillators and feedbacks. Even though this system is vastly complicated, some of the underlying principles are basic and may capture the essence of the climate dynamics at the right time and spatial scale. At this level, there is a wealth of opportunity for incorporation of Earth's climate into mathematics.

In this session, I will start with a brief introduction to conceptual climate models based on the energy balance principle. Then to follow this, I will highlight current efforts and past experiences in bringing Earth's climate into mathematics classrooms and the undergraduate experience using these simple energy balance models. (Received September 19, 2012)

1086-97-1148 **David A. Smith*** (das@math.duke.edu), Durham, NC 27707, and **Lawrence C. Moore** (lang@math.duke.edu). *An Online Calculus Text for the iPad.*

The online textbook, Calculus: Modeling and Application, 2nd edition, published by MAA, is being adapted for reading and interacting on the iPad. The major changes in this adaptation include replacing XHTML pages with HTML, recasting mathematical symbols in MathJax, and replacing use of commercial computer algebra systems with embedded "interacts" that are processed by Sage. Features of the book will be demonstrated directly from an iPad. (Received September 19, 2012)

1086-97-1208 **Al Cuoco*** (acuoco@edc.org), 43 Foundry Ave., Waltham, MA 02453. *High School Teaching: standards, practices, and habits of mind.*

This talk will detail an effort underway in Massachusetts to help high school teachers integrate the Common Core Standards for Mathematical Practice into their work with students.

More precisely, I'll describe a 45-hour course, *Developing Mathematical Practices for Geometry, Algebra II and Beyond*, that takes up standard topics in the high school curriculum and helps teachers use the lens of the standards for mathematical practice and supporting mathematical habits of mind to connect and deepen them, while bringing coherence among them. (Received September 20, 2012)

1086-97-1211 **Genevieve Madeline Knight*** (gmk01@juno.com), P.O. Box 734, Columbia, MD 21045. *The Rest of the Story.*

Profiles of Mathematicians of the African Diaspora* have been compiled and maintained by Dr. Scott Williams, a man of color, who is well known as a distinguished research mathematician, mentor, and teacher. This resource has provided factual information about the lives and works of Black Mathematicians. Events associated with Black Mathematicians have created major benchmarks and milestones in the world of mathematics. Events such as the 1969 Conference of Black Mathematicians at Morgan State College, the founding of the National Association of Mathematicians (NAM), and the establishment of the first Ph.D. program in mathematics at a HBCU, Howard University altered the scope of who participate in the mathematics community. The JMM 2013 Cox-Talbot Lecture will address activities reflecting the philosophies of Cox, Talbot, and other great teachers of mathematics from among Black Mathematicians who make the difference in shaping the mathematics education of ALL students in a global competitive society - 'The Rest of the Story'.

*<http://www.math.buffalo.edu/mad/> (Received September 20, 2012)

- 1086-97-1213 **Al Cuoco*** (acuoco@edc.org), 43 Foundry Ave., Waltham, MA 02453. *Creating a professional community of mathematics teachers.*

For over a decade, teachers, mathematicians, and educators in the Boston area have been building a community of mathematical practice, supported in part by an NSF-funded MSP, *Focus on Mathematics*.

I'll talk about lessons learned in this work and some design principles for creating such communities, principles that have been applied in other settings—the *PCMI Secondary School Teachers Program*, for example. (Received September 20, 2012)

- 1086-97-1222 **Amy Cohen*** (acc@math.rutgers.edu), Rutgers Math / Hill Center, 110 Frelinghuysen Road, Piscataway, NJ 08854. *N. J. Partnership for Excellence in Middle School Mathematics*. Preliminary report.

The N.J. Partnership for Excellence in Middle School Mathematics (NJ PEMSM) is in its 4th year of a 5-year grant from the MSP Program of the NSF. Short-term goals of the project include (1) helping mid-career middle school math teachers to deepen their understanding of the mathematics of grades 6-8 and of some crucial aspects of mathematical pedagogy, (2) improving the capacity of special education teachers to support math teachers, (3) engaging senior mathematicians in work with in-service teachers, (4) enhancing the mathematical education of prospective teachers, and (5) research on teacher learning. Longer term goals of the project include engaging school children more effectively in studying and learning mathematics, and enhancing the capacity of N.J. residents to use mathematical thinking on the job and in civic life. The NJ partnership consists of 15 public school districts, and the Department of Mathematics, the Graduate School of Education, and several other units at Rutgers University. This presentation will discuss the structure of NJ PEMSM, progress toward its goals, and plans to sustain its offerings once the grant is over. (Received September 20, 2012)

- 1086-97-1243 **Barbara Kaskosz*** (bkaskosz@math.uri.edu), Department of Mathematics, University of Rhode Island, 5 Lippitt Road, Kingston, RI 02881, and **Douglas E Ensley**. *Mobile Math Apps: The Smartphone Paradigm*.

We will discuss the demographic trends in smartphone adoption and the implications for education. In addition, we will share recently developed precalculus materials and discuss content, user interface, and the design of assessment tools intended to measure the effectiveness of these materials. Finally, we will discuss the Adobe AIR development process and the ease of portability to other platforms such as Apple iOS. (Received September 20, 2012)

- 1086-97-1273 **Andrew J. Bernoff*** (ajb@hmc.edu), Department of Mathematics, Harvey Mudd College, 301 Platt Blvd, Claremont, CA 91711. *Embracing the iPhone Generation: The Evolving Mathematics Curriculum at Liberal Arts Colleges*.

Google. Twitter. Facebook. The Human Genome. Wolfram Alpha. Smart phones. This generation of liberal arts undergraduates has access to computational resources, social connectivity and scientific data undreamt of a generation ago. Moreover, the internet and these computational resources are the engine driving the job market and opening new fields of academic research. In this talk I will review some initiatives at Harvey Mudd College (and more broadly at liberal arts institutions) responding to these challenges and opportunities. Specifically, I will discuss the growth of our Joint Majors in Mathematics and Computer Science and Mathematical and Computational Biology, the changes in our Mathematics Clinic Program which immerses small groups of students in industrial-sponsored research, and the evolution of our core curriculum to leverage this technology and meet changing student needs. Finally, I will discuss how social media and internet-driven information access is transforming the student experience and some of the pitfalls and opportunities this creates, including pathways for reaching and engaging underrepresented populations in the mathematical sciences. (Received September 20, 2012)

- 1086-97-1367 **William H. Schmidt*** (bschmidt@msu.edu), 620 Farm Lane, 238 Erickson Hall, East Lansing, MI 48824-1034. *Facing the Reality: Reforming the Teacher Preparation Curriculum*.

The adoption of the Common Core State Standards in Mathematics (CCSS) by nearly every state represents an unprecedented opportunity to improve U.S. mathematics teacher preparation. Teachers are particularly important as they operate in the critical arena where standards are translated into learning opportunities and experiences for students.

Beginning in the spring of 2011 the Center for the Study of Curriculum at Michigan State University conducted a survey of teachers of mathematics in the 41 states that had officially adopted the CCSS. This paper presents results from an online survey of over 12,000 teachers of mathematics in grades 1-12. The means for each grade

show that substantially fewer teachers reported feeling academically well prepared to teach CCSS topics than were actually teaching them. This ranged from around 70-80% at the middle and high school levels respectively. These and other data suggest the critical need for the reform of the teacher preparation curriculum. (Received September 21, 2012)

1086-97-1487 **Mike May*** (maymk@slu.edu) and **Tom Banchoff** (banchoff@math.brown.edu).

Rethinking calculus of several variables in the era of computers. Preliminary report.

Traditional multivariable calculus texts written before the development of computer graphing technology emphasized algebraic techniques for analyzing equations. Graphing functions by hand was hard and symbol manipulation dominated, downplaying or eliminating geometric approaches. Even after computer generated illustrations became possible, they often appeared only briefly after which algebra took over. All that has changed with the introduction of readily available tools for visualization and manipulation of three-dimensional graphs and other illustrations. Geometry can take its place along with algebra and numerical techniques at all stages in the study of functions of two and more variables. The authors will discuss advances in visualization technology for teaching and for student use over the past two decades. They will describe and demonstrate their current project, a fully interactive electronic text in multivariable calculus that can give both instructors and students the ability to explore basic phenomena and large families of examples using computer enhanced geometric techniques. (Received September 22, 2012)

1086-97-1490 **Terrence Richard Blackman*** (tblackman@math.mit.edu), 77 Massachusetts Ave, 2-279, Cambridge, MA 02139. *Maple, Mathlynx and The Tablet PC: On the emerging electronic classroom.* Preliminary report.

Tablet PC's are traditional notebook computers with the ability to process handwriting with a electronic pen. The ubiquity of the iPad and other "Tablets" have intensified the debate as to the potential these tools possess for educational use. This paper describes the author's experience using the Tablet PC combined with the Mathlynx Electronic Calculus Text and the Maple Computer Algebra System to conduct Single and Multivariable Calculus Courses at Medgar Evers College over the last three years. Using the Microsoft OneNote software, the Tablet PC was used in the classroom as an enhanced digital whiteboard. The lecture material was archived on Blackboard and made available for future reference by the students. The author offers some insight into the challenges and opportunities concomitant with the use of these tools. Two questions are explored: Do these tools have the potential to positively affect student engagement in the classroom? To what extent do these tools aid in the long term development of a deep conceptual understanding of mathematics? (Received September 22, 2012)

1086-97-1564 **Hyman Bass*** (hybass@umich.edu). *Mathematical Knowledge for Teaching.*

K-20 is a BIG spread, from Kindergarten to PhD courses, from math-TEACHING to MATH-teaching. To form this expanse into a professional community demands a robust appreciation of and sensibility about math on the part of school-teachers and, more radically, a deeper and more sensitive understanding by academic mathematicians of the mathematical work of teaching. We see signs that such a community, of shared commitment and sensibility, is emerging, without infrastructure. There is one site in which the two communities structurally interact—the math content courses for teachers, in which the students are future teachers of children, and the teachers are often academic mathematicians. It is now understood that attending to mathematical integrity does not suffice for the mathematical needs of teaching. Teaching, even at elementary levels, involves special mathematical demands not familiar to most mathematicians, and not treated in academic math courses. Thus instructors in math content courses for teachers need to acquire a substantial knowledge of this specialized mathematical knowledge for teaching (MKT). I will briefly describe some useful sources of MKT, as well as an opportunity to see it deployed in live teaching, in the summer Elementary Math Lab at the University of Michigan. (Received September 23, 2012)

1086-97-1613 **Deborah E. Seacrest*** (d_seacrest@umwestern.edu). *Mathematical Games in Multiple Levels of Education.* Preliminary report.

At the January 2011 Joint Meetings, I reported on the use of educational mathematical games with upper elementary school students. In the spring of 2012, I created an undergraduate general education topics course that used many of the same mathematical games. I taught some of the same topics, as well as some that were more advanced than the elementary school students studied. I previously remarked upon the similarities and differences within the elementary school groups; the comparisons between elementary school students and undergraduate students were perhaps even more interesting and enlightening.

Although many topics were covered in class, this talk will focus on the Towers of Hanoi, One-Pile Nim, and the dice games Pig and Hog. The fact that students in both elementary school and undergraduate classes

enjoyed and learned from these games indicates that they may be especially appropriate in classrooms with diverse groups of learners. (Received September 23, 2012)

1086-97-1618 **Girija S Nair-Hart*** (girija.nair-hart@uc.edu), 3585, Applewood drive, Amelia, OH 45102. *Excavation Definition.*

Mathematics instructors expose students to definitions usually by writing them down on the board and providing examples and non-examples to help clarify the concept. But, we often fail to ask students what they think of that mathematical definition or whether the definition did ‘make sense’ to them. If a concept definition does not make sense to students do we seek out the details of their trouble? Do we seek ways to modify the definition in a manner that that is sense-making to students? During my research on students’ conceptual understanding of asymptotes of rational functions we analyzed the informal definition of asymptotes by Stewart that ‘informally speaking, an asymptote of a function is a line that the graph of the function gets closer and closer to as one travels along that line.’ After debating over this definition, students took turns and drew different figures to accommodate each others perspectives. In the end they unanimously reached consensus on the meaning of this definition and further developed their own definition of asymptotes. This presentation conveys the details of student initiated definition analysis and how if used appropriately, argumentation and debate could provide a powerful tool for a deeper conceptual understanding of mathematics concepts. (Received September 23, 2012)

1086-97-1679 **Guershon Harel*** (harel@math.ucsd.edu), 9500 Gilman Drive, Department of Mathematics, La Jolla, CA 92093. *Developing and Sustaining Professional Communities of Teachers around Mathematical Content and Student Intellectual Need.*

In this talk we discuss our effort to create and sustain a community of teachers organized around a shared purpose and coordinated effort to improve student learning. The collective actions carried out by the community are oriented within a conceptual framework, called DNR-based instruction in mathematics. The hallmark of DNR is that it puts the mathematical integrity of the content taught and the intellectual need of the student at the center of the instructional effort. As an example, we present the community’s effort to implement a DNR-based geometry unit, whose main objective is to help teachers effectively deal with questions such as: How do we intellectually necessitate the abstract nature of geometric objects? How do we intellectually necessitate attention to precise definitions and proofs? How do we intellectually necessitate deductive geometry without attention to axioms and postulates, for which there is little or no place in high-school mathematics? How do we do so and still achieve the ultimate goals expressed in the Common Core State Standards for geometry? (Received September 24, 2012)

1086-97-1690 **J Brian Conrey*** (conrey@aimath.org). *Communities of Problem Solvers.*

I will give some remarks about my personal experience working with the Math Teachers’ Circle program, both in our local MTC and with teams in the early planning stages. (Received September 24, 2012)

1086-97-1746 **Bill Haver*** (whaver@vcu.edu). *Collaboration Among Mathematicians, Mathematics Educators, K-12 Teachers and K-12 Mathematics Supervisors in Virginia.* Preliminary report.

During the past decades, a strong and active partnership has been forged among mathematicians, mathematics educators, K-12 teachers and mathematics supervisors in Virginia. The Virginia Mathematics and Science Coalition has provided a strong environment for our collaboration. Our work has been financially supported by the National Science Foundation, the United States Department of Education, the Virginia Department of Education and the Exxon Mobile Foundation. The presentation will share a number of “lessons learned,” including the need for shared leadership, the importance of K-12 teachers in supporting collaboration between mathematicians and mathematics educators, and the use of grants to support long-term collaboration while accomplishing the specific goals of the grant-funded activity. This collaboration has culminated in a state-wide K-8 Mathematics Specialist initiative through which school-based Mathematics Specialists coach K-8 teachers and lead their school’s mathematics program. Treatment control research has demonstrated the positive impact of these Mathematics Specialists on student learning and teacher beliefs. (Received September 24, 2012)

1086-97-1761 **Carlos Castillo-Garsow*** (cwgc@math.ksu.edu), Dept. of Math, Kansas State University, Cardwell Hall, Manhattan, KS 66506, and **Andrew G Bennett** (bennett@math.ksu.edu), Dept. of Math, Kansas State University, Cardwell Hall, Manhattan, KS 66506. *Developing strong mathematical concepts with multi-touch.* Preliminary report.

The rise of cellphones and touch tablets bring new interface challenges for developing tools for the mathematics classroom. Control of mathlets is typically focused around a mouse: a single point of control with two axes of movement. But what new possibilities open up when multiple points of control become common place? Can

challenging problems or challenging ideas be made more accessible? What sorts of activities and ideas require multiple points of control for students to engage with them? This presentation focuses on how multi-touch interfaces have the potential to aid in developing strong mathematical conceptions that students often struggle with. We will give examples of multi-touch tools for use in the classroom, as well as how they may be used to directly introduce and subtly reinforce strong understandings of core mathematical concepts. (Received September 24, 2012)

1086-97-1764 **Andrew G Bennett*** (bennett@math.ksu.edu), Dept. of Math, Kansas State University, Cardwell Hall, Manhattan, KS 66506, and **Carlos W Castillo-Garsow** (cwcg@math.ksu.edu), Dept. of Math, Kansas State University, Cardwell Hall, Manhattan, KS 66506. *C³ Institutes for improving teachers understanding of mathematics and pedagogy*. Preliminary report.

For a decade, we have run two-week summer institutes which teach a combination of mathematical content and pedagogy to K-12 (primarily 4-9) teachers. With the development of the common core standards, these institutes have worked well to help teachers understand what mathematics is being required and how to address the demands of the new standards. These institutes help develop teachers who can support student interns' growth. They also provide us with solid lines of communications between teachers and university faculty that serve us well when we need to work together in the preparation of new teachers. (Received September 24, 2012)

1086-97-1788 **Jennifer Slimowitz Pearl*** (jslimowi@nsf.gov), Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230. *New NSF initiative: "Expeditions in Training, Research, and Education for Mathematics and Statistics through Quantitative Explorations of Data" (EXTREEMS-QED)*.

We will discuss the recently announced NSF solicitation "Expeditions in Training, Research, and Education for Mathematics and Statistics through Quantitative Explorations of Data" (EXTREEMS-QED). EXTREEMS-QED supports efforts to educate the next generation of Mathematics and Statistics undergraduate students to confront new challenges in computational and data-enabled science and engineering. While the first deadline for EXTREEMS-QED proposals will have already passed by the time of the JMM, we anticipate a second competition deadline in the fall of 2013. This presentation will inform Mathematics and Statistics departments interested in developing early interdisciplinary research experiences and innovative curricula in computational and data-enabled science and engineering, creating new learning environments, and sustaining the professional growth of faculty. (Received September 24, 2012)

1086-97-1999 **W. James Lewis*** (jlewis@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *NebraskaMATH: Building partnerships to strengthen mathematics teaching and learning in Nebraska*. Preliminary report.

NSF's Math Science Partnerships program offers opportunities for mathematicians to assume significant roles focused on the mathematical education of teachers. Because the work is interdisciplinary, a successful MSP requires forming partnerships with colleagues in other departments and partnerships between the K-12 community and the higher education community. At the University of Nebraska-Lincoln, we have been fortunate to have two NSF funded Math Science Partnerships (Math in the Middle and NebraskaMATH) and one NSF funded Noyce grant that support such partnerships. We will discuss how these partnerships were developed and the benefits to faculty and graduate students in the Department of Mathematics. (Received September 24, 2012)

1086-97-2013 **Ben McCarty*** (bmmccrt1@memphis.edu). *Quality Problems Through Collaboration*. Preliminary report.

A collaborative effort between educators and mathematicians has the potential to produce tasks that probe deep levels of understanding, and guide students toward the goals laid out by the Common Core State Standards for Mathematics. We will look at the impact such collaboration is having on the production of quality tasks for the Illustrative Mathematics Project. (Received September 24, 2012)

1086-97-2028 **Margo Alexander*** (malexander@gsu.edu), 30 Pryor Street, Suite 750, Atlanta, GA 30303, and **Iman Chahine**. *Team Teaching with Math History and Ethnomathematics*. Preliminary report.

There has been a growing recognition among educators of the important role through intercampus collaboration can have in enhancing many aspects of teaching and learning. Team teaching is valuable for promoting integrative thinking but it is costly to commit multiple faculty to one course. However, this major university sees the benefits and is willing to go the extra mile to facilitate in the improvement of instruction. The collaboration will be between a mathematicians course of the History of Mathematics and a mathematical educators course

of Ethnomathematics. The primary purpose of this study is to provide students with an alternative lens to view mathematical knowledge as it transpired across civilizations and within various non-western cultures and to help endow students with the necessary predispositions to look at the world through ethnomathematical eyes. That is, this course dovetails two components: the exploration of the historical development of mathematics and second, culturally immersing students firsthand in a field experience of an authentic, elusive, and problematic diverse setting. The purpose of this talk is to describe the impact of this teaching and learning experience as well as student perceptions. (Received September 24, 2012)

1086-97-2062 **Ben Ford, Brigitte Lahme*** (brigitte.lahme@sonoma.edu) and **Katherine Morris**.

Working with K-12 teachers changes our practice. Preliminary report.

Sonoma State University has a long professional development partnership with area schools. We'll discuss the impacts on our own University teaching which has resulted from this work: Lesson study at the University level, teaching practices we have adopted from the K-12 world, more thoughtful and careful approaches to pedagogy, and increased collaboration among faculty. (Received September 24, 2012)

1086-97-2109 **Paul E Seeburger*** (pseeburger@monroecc.edu), Monroe Community College, 1000 E.

Henrietta Rd., Rochester, NY 14623. *Playing with Multivariable Calculus Concepts*

Wearing 3D Glasses. Preliminary report.

A tour of an NSF-funded project that seeks to develop geometric intuition in students of multivariable calculus. This online exploration environment called CalcPlot3D allows students (and instructors) to create and freely rotate graphs of functions of two variables, contour plots, vectors, space curves generated by vector-valued functions, regions of integration, vector fields, parametric surfaces, implicit surfaces, etc. 3D glasses can be used for a real 3D perspective! Come get a pair and try it out! A series of four assessment/exploration activities has also been created to help students "play" with the 3D concepts themselves, and to assess improvements in geometric understanding gained from these activities. Topics of these explorations include Dot Products, Cross Products, Velocity and Acceleration Vectors, and Lagrange Multiplier Optimization, and more are being developed. Preliminary results of the first four years of these assessments will be shared briefly. Short video lessons using the applet to visually verify lecture examples have also been created. The grant project is titled, Dynamic Visualization Tools for Multivariable Calculus (NSF-DUE- CCLI #0736968). See <http://web.monroecc.edu/calcNSF/>. (Received September 24, 2012)

1086-97-2174 **Jazlynn Q Ngo*** (jazziengo@gmail.com). *Triangular modulation of downstream surface waves of water flows over a bump.*

The forced Korteweg-De Vries is used to model surface waves of water flows over a bump. The fKdV has four known types of solutions depending on the upstream current speed λ and the size of the bump P : sub-critical cnoidal waves, a hydraulic fall, transcritical waves and supercritical solitary waves. This paper will focus on the analysis of the downstream cnoidal wave modulation. The wave modulation varies according the control parameters λ and P . We will explore the range these parameters that are required for the downstream surface waves of water flows to form a triangular modulation. In particular, we will provide an approximate analytic description of the triangular modulation of the downstream cnoidal waves. The analytic solutions will be validated by numerical solutions. (Received September 25, 2012)

1086-97-2193 **Emily S Cilli-Turner*** (ecilli2@uic.edu), 851 S. Morgan, M/C 249, Chicago, IL 60608.

Proof Construction and Collaborative Revision in Undergraduate Mathematics.

Preliminary report.

Although the ability to construct proofs is an integral part of being a mathematician, it is well documented that many undergraduate students struggle when faced with this task. Additionally, there is evidence that students do not understand the myriad roles that proof plays in mathematics. Thus, teaching methods need to be developed that highlight different roles of proof and are effective in aiding students with proof construction skills. In this project, the effects on student thinking about the role of proof in mathematics, student ability to judge the validity of a proof, and student proof construction of teaching proof through the process of collaborative revision will be examined. Collaborative revision refers to the process in which students present a proof they have constructed to their classmates and the other students are encouraged to make comments and point out inconsistencies in order to ensure that the proof is valid. Pre and post assessments were given to students, classroom observations will be completed and student proof portfolios will be collected. The research questions will be addressed by a mixed method analysis of data collected from treatment and comparison groups. (Received September 25, 2012)

1086-97-2249 **Peter R. Turner*** (pturner@clarkson.edu). *SIAM NSF Workshop on Modeling across the Curriculum.*

In this talk, the recent SIAM-NSF Workshop on Modeling across the curriculum (August, 2012) will be described, and an introduction to the report will be presented. The meeting proposal pre-dated but responded to the PCAST "Engage to Excel" report and its call for one million new college STEM graduates in the next decade. The meeting had three primary themes: bringing coordinated STEM curriculum content into the middle and high schools within the framework of the common core standards; undergraduate curricula in modeling and computational applied mathematics as the heart of a STEM undergraduate experience; and readiness for college STEM education on graduation from High School. The last theme essentially acts as a basis for assessment of the programs that are developed and how they address the "math gap" often experienced on entry to college degree programs in STEM fields. (Received September 25, 2012)

1086-97-2273 **Davide P. Cervone*** (dpvc@union.edu), Department of Mathematics, Union College, Schenectady, NY 12308. *MathJax from an Author's Point of View.*

MathJax allows authors to include mathematics easily in their web pages using L^AT_EX notation, MathML, or AsciiMath syntax, and generates high-quality output using either HTML-and-CSS, SVG, or MathML. For pages with static content, adding a single line to your HTML files is all that is needed to have MathJax process its mathematical content; dynamic pages require a bit more interaction with MathJax. This talk will present an overview of some of the techniques for using MathJax interactively within your pages that include dynamic content, and how to use its configuration options to customize MathJax to your needs. (Received September 25, 2012)

1086-97-2305 **David Bressoud*** (bressoud@macalester.edu). *Reflections on Modeling based on the MAA National Survey of Calculus.* Preliminary report.

MAA's national survey of Calculus I, undertaken in 2010 in conjunction with the CBMS Survey of Undergraduate Programs in the Mathematical Sciences, reveals trends and patterns that can inform efforts to bring more modeling into the curriculum. This will be a presentation of some of these descriptive data. (Received September 25, 2012)

1086-97-2458 **Sabrina A. Hessinger*** (sabrina.hessinger@armstrong.edu), 11935 Abercorn Street, Savannah, GA 31419. *Georgia's Partnership for Reform in Science and Mathematics: Phase I large scale implementation and Phase II rigorous research.*

The Partnership for Reform in Science in Mathematics (PRISM) Phase I was a large scale comprehensive MSP with a focus on implementation of ten integrated strategies involving 17,000 teachers and over 500 higher education (IHE) faculty. In PRISM Phase II, collaborative research teams systematically investigated the most successful strategies from PRISM Phase I: 1) culture change in higher education and 2) the implementation and impact of learning communities involving both K-12 and IHE faculty. Within these two projects, mathematicians assumed a variety of roles including development of the state level K-12 math standards, designing courses and co-teaching with exceptional K-12 teachers, engaging in professional learning communities focused on effective teaching of mathematics, and engaging in collaborative research teams. Evidence of positive impact includes changes in departmental culture, increased use of student centered teaching practices, development of skill in classroom research, and improved student success at both the K-12 and higher education level. Armstrong continues to implement successful research focused learning communities through the support of the provost as well as through our Noyce grant: Building STEM Teachers through Cohorts and Communities. (Received September 25, 2012)

1086-97-2464 **Sybilla Beckmann*** (sybilla@math.uga.edu), Department of Mathematics, 200 D. W. Brooks Drive, University of Georgia, Athens, GA 30602, and **Jacob Hicks**. *The Mathematics Teaching Community.*

The Mathematics Teaching Community, <https://mathematicsteachingcommunity.math.uga.edu/> is an online community for exchanging ideas about mathematics teaching and the context in which it occurs. Mathematics teaching needs improvement at all levels and a flow of information across levels. Sustaining work towards excellence over the long run requires considerable motivation. Yet research on motivation indicates that popular approaches to improving teaching through external evaluation are unlikely to help mathematics teaching become a stronger and more vibrant profession.

The Mathematics Teaching Community aims to promote work towards excellence in mathematics teaching by fostering competition for the admiration of one's peers. The site was designed to allow members to develop a

reputation based on other members' views on the quality of postings. The community can also vote down ideas that it finds unhelpful or bad.

Users of the Mathematics Teaching Community can attach tags to their submissions, allowing others to search for and find topics of interest. By posting comments and related submissions, discussions can build on each other, and ideas can evolve and be refined over time.

A current challenge for the site is how to become noticed and attract participants. (Received September 25, 2012)

1086-97-2504 **Katherine Socha*** (ksocha@mathforamerica.org). *Coursework in Applied and Computational Mathematics at the High School Level*. Preliminary report.

Last Fall, the working group discussions on possible 'Intro to STEM' coursework at the high school level were wide-ranging, thoughtful, and provocative. This portion of the mini-symposium will provide an overview of our critical questions, discuss data likely needed to address the questions, make recommendations for next tasks (including research topics), and explore links with both college readiness and undergraduate curriculum issues. Even within our small working group, many different viewpoints were expressed about the presence, success, and appropriate role of applied and computational mathematics within the K-12 educational framework. Please join us to explore these ideas further in a constructive conversation. (Received September 25, 2012)

1086-97-2511 **David Jabon*** (djabon@depaul.edu), DePaul University, Chicago, IL 60614, and **Carolyn Narasimhan** (cnarasim@depaul.edu), DePaul University, Chicago, IL 60614. *Models for creating dialogue between mathematics and science teachers about the Common Core Standards and the Next Generation Science Standards*.

The release of the Common Core Standards in Mathematics and the imminent release of Next Generation Science Standards present the mathematics community a unique and important opportunity to engage in discussions about high quality learning in both math and science teaching. For example, it is important for science teachers to be aware of the depth of thinking the standards for mathematical practice demand, and math teachers benefit greatly from learning how to use authentic scientific tools and contexts in the classroom especially with the increased emphasis on mathematical modeling in the standards. This talk describes several early models we have attempted that have potential for creating dialogue and cross fertilization of ideas between math and science teachers in light of the standards. Among the models are: engaging students in authentic classic science experiments in the mathematics classroom using sensors connected to ordinary graphing calculators as well as using video capture, creating opportunities for teachers to interact directly with scientists and hear about their work, and engaging science and math teachers in conversations about the mathematical practices. (Received September 25, 2012)

1086-97-2556 **Daniel L Goroff*** (goroff@sloan.org). *Big Data Projects: Lessons Learned and To Be Learned*. Preliminary report.

Drawing on experience supporting the Sloan Digital Sky Survey, the Census of Marine Life, Wikipedia, the Barcode of Life, Legal Entity Identifiers, and similar large scale data projects, the Alfred P. Sloan Foundation has developed some unusual perspectives on the implications of "big data," both for what we teach and how we teach. Successful empirical research requires early attention to hypothesis formulation, experimental design, data infrastructure, metadata standards, privacy and proprietary restrictions, as well as many other challenges that mathematicians can help address. (Received September 25, 2012)

1086-97-2599 **Robert E. Megginson*** (meggin@umich.edu), 3301 E. Dobson Pl., Ann Arbor, MI 48105. *Mathematical sense and nonsense in the public conversation about the future of Planet Earth: How do we help our students tell the difference?* Preliminary report.

Many areas of the public dialog about the future of our planet, particularly those involving climate change, have become highly politicized, contentious, and confusing to the general public. As a discipline, mathematics often puts forth the idea that one of its great values is that it helps teach students to think logically. In the area of climate science in particular, but in STEM applications to our planet more generally, we are not always succeeding as well as we should, judging from some of the mathematically fallacious arguments that appear and are accepted in that public dialog. In this talk, some examples will be given, along with the portions of the Standards for Mathematical Practice that address this very issue, with the hope that we can have a conversation about how the Standards provide a tool for addressing this matter at every grade level. (Received September 25, 2012)

- 1086-97-2610 **James R King*** (king@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350. *Northwest Mathematics Interaction: Two Decades of Math Learning and Sharing.*

NWMI started in the early 90s as a group of teacher participants in the Park City Mathematics Institute who gathered in Seattle during the academic year to do mathematics with mathematicians at the University of Washington. In 1995 the group began organizing and presenting weeklong summer programs (17 so far) and academic-year Saturday workshops, with an emphasis in geometry. A hallmark of the group has been the collegial and informal interaction and shared leadership among the secondary and university members of the group. The presentation will describe some experiences and lessons learned from this history. (Received September 25, 2012)

- 1086-97-2672 **Ron Buckmire*** (rbuckmir@nsf.gov). *Mathematicians and Scientists working together in K-12 Education: Opportunities within the NSF Mathematics and Science Partnership (MSP) Program.*

This presentation will feature an overview of the NSF Mathematics and Science Partnership (MSP) program, covering its origins, its mission, and its operational goals. Funding tracks will be described that provide opportunities 1) for mathematicians to partner with mathematics educators and other scientists, and 2) for members of the higher education community to collaborate with counterparts in the K-12 enterprise, to improve K-12 STEM education. Observations will also highlight the key role for mathematicians to play in MSP projects and, more generally, to take on leadership in this important aspect of K-12 education. (Received September 25, 2012)

- 1086-97-2732 **Susan D. Nickerson*** (snickers@sciences.sdsu.edu), SDSU, Department of Mathematics and Statistics, San Diego, CA. *Opportunities and Challenges in Teaching Mathematical Modeling.* Preliminary report.

Estimating the density of marine populations by categorizing audio signals, quantitatively describing the effect of human activity in drought-induced fires, and measuring natural disasters such as earthquakes are examples of relevant local topics that can engage secondary teachers and students.

The secondary school curriculum as envisioned by the authors of the Common Core Standards (CCSS) and the Next Generation Science Standards (NGSS) describes major changes not only in content but also in students' ability to engage in the practice of modeling. Students are expected to collect data, choose appropriate tools to make predictions, test, and revise models, rather than just represent and describe data. This presents a new challenge for teachers.

In this presentation I will share data on what teachers understand about modeling as described in the Standards for Mathematical Practice and the Next Generation Science Standards. This data helps us design professional development experiences for teachers as they support their students in meeting the new expectations. (Received September 25, 2012)

- 1086-97-2736 **Diana White*** (diana.white@ucdenver.edu), Department of Mathematical & Statistical Scie, University of Colorado Denver, Campus Box 170, P.O. Box 173364, Denver, CO 80217. *A qualitative look at the co-instructional model of the Intel Math professional development program for K-8 teachers.* Preliminary report.

Intel Math is a highly structured, 80-hour professional development course in mathematics content for K-8 teachers focused primarily on mathematical ideas in the K-8 curriculum. Adapted from the Vermont Math Initiative, one of the goals of Intel Math is that teacher-participants deepen their own understanding of math through problem-solving. A unique features of an Intel Math course is that it is always co-taught by a mathematician and a mathematics educator.

A team consisting of a mathematician and an elementary math coach conducted an in-depth qualitative look at the Intel Math instructional model, based on analysis of video from eight instructional teams. The purpose of looking at the instruction of these teams was to better understand how the Intel Math instructional model plays out in practice. The teams with the most active and engaged participants had noteworthy aspects that went beyond the basic model that were visible in their instruction. We believe that these contributed to their participants' engagement. This talk provides additional detail on the basic Intel Math model, the analysis process, and the evidence to support our conclusions. (Received September 25, 2012)

- 1086-97-2792 **William Barker*** (barker@bowdoin.edu), **Andrew Bernoff**, **Ingrid Daubechies**, **Daniel Goroff** and **Jennifer Slimowitz Pearl**. *Computational Sciences and Big Data: Implications for the Mathematics Curriculum — A Discussion*. Preliminary report.

The growing importance of the computational sciences—fueled in part by the need to analyze increasingly massive data sets—presents both a challenge and an opportunity for mathematics education. What are the fundamental implications for the undergraduate curriculum? How do these implications vary among differing types of institutions, e.g., liberal arts colleges versus research universities? To what degree should interdisciplinary collaboration be part of the response to this challenge? The discussion will provide advice and guidance for mathematics departments addressing this curricular issue. (Received September 25, 2012)

- 1086-97-2827 **Marilyn E. Strutchens*** (strutme@auburn.edu), 1955 St Charles Court, Auburn, AL 36830. *Preparing and Supporting Mentor Teachers of Field Experiences for Secondary Mathematics*.

In this session we will discuss issues related to preparing and supporting mentor teachers of field experiences for secondary mathematics education students. Participants will learn about knowledge, skills, and other needs that mentoring teachers have related to being able to mentor preservice teacher effectively in the context of implementing the Common Core State Standards. Innovative program components and other strategies designed to meet the aforementioned needs will also be discussed. (Received September 25, 2012)

- 1086-97-2909 **William McCallum*** (wmc@math.arizona.edu). *Integrating the CCSS practice standards into mathematics teaching*. Preliminary report.

The Common Core State Standards include standards for content (what mathematics students should learn) and standards for practice (how students should do mathematics). The practice standards have attracted a lot of admiration, but there is a danger that they will be taught as free-floating proficiencies. In this presentation we will discuss briefly how the practice standards can be embedded into the content standards. (Received September 26, 2012)

- 1086-97-2921 **Imre Tuba*** (ituba@mail.sdsu.edu), San Diego State University, Imperial Valley, 720 Heber Ave, Calexico, CA 92231, and **Jeffrey Burt** (jeffdburt@gmail.com), 1664 Driftwood Dr, El Centro, CA 92243. *Increasing retention of beginner secondary mathematics teachers through professional community building*.

STRIVE, a professional development project funded by the Supporting Teachers in Retention initiative of the California Mathematics Project, ended just recently. Its goal was to reduce the high attrition rate among beginner secondary mathematics teachers in Imperial County of California through better preparing them for their jobs by increasing their pedagogical mathematics content knowledge and improving their leadership skills. While the project did both, it also achieved its primary goal of significantly reducing attrition among participating teachers. What emerged in the process is a strong professional community of mathematics teachers who continue to support each other. We will describe how this professional community was created and how it contributed to increasing the retention of beginner mathematics teachers. (Received September 26, 2012)

- 1086-97-2935 **Dan Maki*** (maki@indiana.edu) and **Lee L. Zia** (lzia@nsf.gov). *Mathematicians and Scientists working together in K-12 Education - a Discussion*.

The NSF Mathematics and Science Partnerships (MSP) program supports projects in which mathematicians collaborate with mathematics educators and other scientists, as well as key partners in the K-12 enterprise, to improve K-12 STEM education. At this time, the previous speakers and the audience will have an opportunity to discuss the talks and the opportunities for mathematicians to be involved in MSP projects. (Received September 26, 2012)

- 1086-97-2938 **William McCallum*** (wmc@math.arizona.edu), Department of Mathematics, The University of Arizona, Tucson, AZ 85721, and **David Jabon**, **Carolyn Narasimhan**, **Al Cuoco** and **Helen Quinn**. *Standards for practice in the mathematics and science standards: a discussion*. Preliminary report.

The K-12 Common Core State Standards for Mathematics are comprised of standards for mathematical content and for mathematical practice. The practices they describe are supported by mathematical habits of mind. The National Research Council's Framework for K-12 Science Education, which will be the basis for the Next Generation Science Standards, describe scientific practices, some of which are the same or similar to mathematical practices. Each talk in this session focuses on these practices, and how teachers can be supported in helping their students to achieve the related standards. At the end of the session, the speakers and the audience will have an opportunity to discuss the talks and related issues. (Received September 26, 2012)

1086-97-2966 **Helen Quinn***, quinn@slac.stanford.edu. *Scientific practices in the Next Generation Science Standards*. Preliminary report.

In this talk I will compare the practices described in the National Research Council's Framework for K-12 Science Education, the basis for the Next Generation Science Standards, with the Standards for Mathematical Practice in the Common Core State Standards in Mathematics. (Received September 26, 2012)

1086-97-2993 **Ron Buckmire*** (rbuckmir@nsf.gov), National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230. *Discussion on the SIAM-NSF Workshop Report and next steps*. Preliminary report.

This talk will focus on the SIAM-NSF Workshop Report and next steps. (Received October 01, 2012)

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MAA ABSTRACTS

MAA Invited Addresses, SIGMAA Guest Lectures, and Presentations by Teaching Award Winners

1086-A0-10 **Suzanne Weekes***, Worcester Polytechnic Institute. *Industrial strength mathematics in academia.*

“I like math a lot, but what can I do with it other than teach?”

In order to enhance the educational and research experiences for students and faculty and to help make new contacts with business and industry, the Center for Industrial Mathematics and Statistics (CIMS) was established at Worcester Polytechnic Institute (WPI) in 1997. Faculty and students work with our industrial partners on real-life problems that are of both industrial and mathematical significance.

CIMS research activities have included research projects for mathematical sciences majors during the regular academic year; the WPI REU Program in Industrial Mathematics and Statistics which has been supported by the National Science Foundation (DMS 9732338, DMS 0097469, DMS 0353816, DMS 0649127, DMS1004795) and the ASSURE program of the Department of Defense; supporting and hosting the Mathematical Problems in Industry Workshop (NSF-0753050); and the Mathematics in Industry Institute for Teachers.

In this talk, we will give more details and examples of the research and educational partnerships that we have made with the over 50 companies that we have worked, some research problems that students have tackled, the skills that we see are needed to be successful working with and in industry, and the challenges that one may face when working with corporate partners. (Received April 10, 2012)

1086-A0-11 **Tony DeRose***, Pixar Studios. *How mathematics has changed Hollywood.*

Over the past two decades filmmaking has been completely revolutionized by advances in areas such as computational physics and applied math. Using numerous examples drawn from Pixar’s films, this talk will provide a behind the scenes look at the role that mathematics has played in the revolution. (Received April 10, 2012)

1086-A0-12 **Chris Rasmussen***, San Diego State University. *Who chooses not to persist in Calculus and why?*

The transition from high school to college mathematics is one of the most critical junctures in the preparation of individuals to meet the mathematical demands of the 21st century in science, technology, engineering, and mathematics (STEM). Even while more students are taking more advanced mathematics in high school than ever before—including over half a million each year who study calculus while in high school—the percentage of all college students in 4-year undergraduate programs who are enrolled in mathematics at the level of calculus or above has decreased steadily over the past decades. Moreover, a substantial percentage of students who enroll in Calculus I intending to take more Calculus end of deciding not to continue in Calculus. This represents a huge loss to the nation in terms of the need for more students to pursue a major in one of the STEM disciplines. In this presentation I examine the characteristics of STEM intending students who begin their post secondary studies with Calculus I and either persist or switch out of the Calculus sequence, and hence either remain or leave the STEM pipeline. The data used for this analysis comes from a unique, in depth national survey aimed at identifying characteristics of successful programs in college Calculus. (Received April 10, 2012)

1086-A0-13 **Timothy Chartier***, Davidson College. *Thinking linearly about data.*

From sports to social networks to movie ratings, data sets ever increase in size and availability. Mining such masses of information for meaning is common and an active area of research in science and business. This talk will discuss techniques in ranking and clustering that rely on linear algebra. Recent work will be discussed as well as how to present such work at the undergraduate level for research and in classes for math majors and nonmajors.. (Received April 10, 2012)

1086-A0-14 **Paul Zorn*** (zorn@stolaf.edu). *Communicating Mathematics.*

Mathematicians don’t just *do* mathematics. We communicate our subject too, by speaking, writing, teaching, illustrating, editing, explaining, and professing it, for expert and non-expert audiences alike. Words, pictures, equations, and other media may be well or poorly suited to the special purposes of mathematical exposition, and mathematical exposition may be good, bad, or indifferent, depending largely on its audience. But, as I will argue with examples, mathematical exposition is at its best real and valuable mathematics — and no less challenging

or deserving of professional reward than other forms of mathematical activity. Mathematics is a big tent, and its vitality and growth depends on contributions from many directions. (Received September 25, 2012)

1086-A0-57 **Judith Covington***, Louisiana State University Shreveport, Shreveport, LA. *The game of SET and geometry.*

What exactly does the game of SET have to do with geometry? The game of Set deals with matching or not matching four different characteristics. Geometry deals with points, lines and planes. This talk will briefly describe the game of set and discuss how to use the SET cards to describe a finite geometry model. (Received June 25, 2012)

1086-A0-67 **Joseph M. Mahaffy***, San Diego State University, San Diego. *Modeling and calculus for the life sciences with WeBWorK computer labs.*

Students learn better in a contextual environment with active participation. I have developed a Calculus course, which uses a modeling-based approach to learning the material and has computer labs with data-based examples to give hands on modeling experience with real biological examples. In the computer lab the students obtain experience with software tools to manage real data sets and practice the knowledge learned from the lectures. Several specifics examples will be presented.

WeBWorK is an open source, automated homework system supported by the MAA. As an open source development tool, I have created many biologically based homework exercises. More recently, I have extended WeBWorK exercises to include a significant portion of the computer lab problems. The computer lab problems include a graphing and writing component to further promote the understanding of key concepts. Former students have related that the computer lab was their most valuable learning experience, which carried through the rest of their university career. (Received July 03, 2012)

1086-A0-68 **Mario Livio***, Space Telescope Science Institute, Baltimore, MD. *Is God a mathematician?*

For centuries, mathematical theories have proven uncannily accurate at describing—and predicting—the physical world. What is it that gives mathematics such powers? I will thoroughly review this question in “Is God A Mathematician?” (a talk based on my popular book). The talk will span such fields as mathematics, cosmology, physics, and the cognitive sciences, and will attempt to offer an accessible and lively account of the ideas of some of the greatest mathematicians and scientists in history, from Archimedes to Galileo and Descartes, and from Newton to Hilbert and Gödel, on up to the present day. Along the way I will discuss another question with which mathematicians, philosophers, and neuroscientists have struggled for centuries: Is mathematics ultimately invented or discovered? (Received July 03, 2012)

1086-A0-69 **Keith Devlin***, Stanford University, Stanford, CA. *Leonardo Fibonacci, Liber abbaci, and the rise of the modern commercial world.*

The first personal computing revolution took place not in Silicon Valley in the 1980s but in Pisa in the 13th Century. The medieval counterpart to Steve Jobs was a young Italian called Leonardo, better known today by the nickname Fibonacci. Thanks to a recently discovered manuscript in a library in Florence, the story of how this little known genius came to launch the modern commercial world can now be told. How we came to know there even was a revolution, and Leonardo’s role in it, is a fascinating story in its own right. (Received July 03, 2012)

1086-A0-72 **Mark Balaguer*** (mbalagu@exchange.calstatela.edu), Department of Philosophy, California State University–Los Angeles, Los Angeles, CA 90032. *A Guide for the Perplexed: What Mathematicians Need to Know to Understand Philosophers of Mathematics.* Preliminary report.

In this lecture, I will attempt to clarify some things about the methodology of the philosophy of mathematics—about the kinds of theories that philosophers of mathematics can be seen as primarily putting forward and about the kinds of arguments that they use to justify these theories. I will also try to clarify the relationship between mathematics and philosophy of mathematics. (Received September 24, 2012)

1086-A0-73 **Davide Cervone***, Union College, Schenectady, NY. *MathJax: The present and the future.*

MathJax is one of the primary means of displaying mathematics on the web, and it is being incorporated into e-book readers, mobile apps, and other platforms as well. The recent release of version 2.0 brings a range of new functionality and performance improvements, including new input formats and output renderers. We will present the basics of how to use MathJax in your own pages and configure it for your needs, demonstrate some

of the ways that it can be used in web sites with dynamic content, and discuss the directions of current and future MathJax development. (Received July 05, 2012)

1086-A0-113 **Cynthia Woodburn*** (cwoodburn@pittstate.edu), Mathematics Department, Pittsburg State University, 1701 S. Broadway, Pittsburg, KS 66762. *Geometry and Baroque Architecture in Turin, Italy*. Preliminary report.

This talk will focus on the work of Guarino Guarini: a priest, mathematician and architect of the 1600's, who designed many buildings in Turin, Italy and other European cities. As a mathematician, Guarini studied and wrote about geometry, and then he applied his knowledge to architecture. He is especially known for the use of curvature and projection, and his buildings served as a model for future architects. Included in the talk will be pictures from several Guarini buildings visited during the 2012 MAA Study Tour of Italy. (Received July 22, 2012)

1086-A0-2999 **Francis Su***, Harvey Mudd College, Pomona. *Weakness to wholeness: the struggle and the hope*

Beyond basic instructional techniques, we can learn a lot about teaching by learning to be authentic with students about our struggles and our hope. (Received October 11, 2012)

1086-A0-3000 **Margaret Robinson***, Mount Holyoke College, South Hadley, MA. *Students into Mathematicians: Twenty-five years teaching at a liberal arts college for women*.

As teachers, we try to inspire students to appreciate the process of learning mathematics and also to experience what is involved in doing mathematics at a high level. An early influence on my career was teaching Mount Holyoke's laboratory mathematics class, which is designed to teach mathematics by having students discover and prove results as a mathematician would. Soon I was also involved in leading research groups in our summer REU program. In my classes today, I focus on making my students think and feel like mathematicians. In this talk, I will discuss these experiences and outline some ideas to keep in mind when planning and teaching classes. (Received October 11, 2012)

The Beauty and Power of Number Theory

1086-AB-524 **Alice Silverberg*** (asilverb@uci.edu). *Primality proving and elliptic curves*.

This talk will include a short survey of primality proving, especially primality proving using elliptic curves. We will also mention recent joint work with Alexander Abatzoglou, Andrew Sutherland, and Angela Wong on deterministic primality proving in special sequences. (Received September 05, 2012)

1086-AB-684 **Chantal David*** (cdavid@mathstat.concordia.ca) and **Ethan Smith** (ethansmith@gmail.com). *Groups of elliptic over finite fields and the Cohen-Lenstra Heuristics*.

Let G be an abelian group of rank 2 and order N , let $M_p(G)$ be the number of elliptic curves over the finite field \mathbb{F}_p with group of points isomorphic to G . We study in this talk the average of $M_p(G)$ over the prime fields \mathbb{F}_p , in particular how the average varies with the structure of the group G . We find that this variation is governed by the Cohen-Lenstra Heuristics, which predict that random abelian groups occur with probability weighted by $\#G/\#\text{Aut}(G)$ where $\text{Aut}(G)$ is the number of elements of the automorphism group of G . This variation can also be seen when we forget the group structure, and look at the average number of curves with a fixed number of points over \mathbb{F}_p .

This is joint work with E. Smith.

(Received September 11, 2012)

1086-AB-971 **Richard K Guy*** (rkg@cpsc.ualgary.ca), Department of Mathematics and Statistics, The University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada. *Reg & Neg*.

The beauty and power of (regular, simple) continued fractions is well-known, but **negative** continued fractions deserve equal time. To find the **neg** of x , subtract it from its **roof**, \hat{x} , the least integer strictly greater than x . When x is an integer, the roof is higher than the ceiling. Then take the reciprocal of the difference and repeat, keeping a record of the roofs. The first one is the **integer part**; the rest are **partial quotients**. Notice that the process doesn't terminate. We will explore several places where negs do a better job than regs. (Received September 17, 2012)

1086-AB-1156 **Michael A. Bennett*** (bennett@math.ubc.ca), Department of Mathematics, 1984 Mathematics Road, Vancouver, BC V6T 1Z2, Canada, and **Imin Chen**, **Sander Dahmen** and **Soroosh Yazdani**. *Generalizing Fermat's Last Theorem*. Preliminary report.

In this talk, we will survey the "state-of-the-art" on generalized Fermat equations of the shape $x^p + y^q = z^r$, where p, q and r are positive integers, the sum of whose reciprocals is less than 1. We will concentrate on infinite families of exponent triples where the corresponding equations have been shown to have no solutions, via methods based upon the modularity of associated Galois representations. Hopefully, we will sketch some future directions of promise. This is joint work with Imin Chen, Sander Dahmen and Soroosh Yazdani. (Received September 19, 2012)

Energy, Population, and Sustainability

1086-AC-999 **Martin E. Walter*** (martin.walter@colorado.edu). *The Logic of Nature Versus the Logic of Industrial Humans: End Game*. Preliminary report.

Our working definition of mathematics for this talk is: the search for and study of patterns. Building on the analysis and examples in the text, "Mathematics for the Environment," we give a self-contained look at actual, unsustainable, patterns in how our civilization acquires essentials such as energy, water, and food. We compare these with alternative patterns, that are mathematically possible and sustainable. We also look at processes that affect decision-making, such as certain aspects of our financial system, that are logically flawed from the standpoint of sustainability. (Received September 17, 2012)

1086-AC-1075 **Abdul-Aziz Yakubu*** (ayakubu@howard.edu), 2441 6th Street NW, Department of Mathematics, Howard University, Washington, DC 20059, and **Avner Friedman** (afriedman@math.osu.edu), Department of Mathematics, The Ohio State University, Columbus, OH 43210. *Impact of host demographic Allee effect, fatal disease and migration on biodiversity*.

In this talk, we will focus on biodiversity, a major problem for ecosystem resilience. Using extensions of the Susceptible-Infected epidemic model of Hilker et al. we will illustrate how population persistence or extinction of a vulnerable species relates to habitat dependent Allee thresholds, fatal disease dynamics and migration rates in both discrete and continuum set of compartments. We will analyze the migration-linked models and establish verifiable conditions that guarantee host population persistence (with or without infected individuals) or extinction. (Received September 18, 2012)

1086-AC-1251 **Fred Roberts*** (froberts@dimacs.rutgers.edu), DIMACS, Rutgers University, 96 Frelinghuysen Road, Piscataway, NJ 08854. *Measurement of Biodiversity*.

One of the great concerns with climate change and global change more generally is the effect on the diversity of life on the planet and an indicator of global change is the level of biodiversity. There is a long history of attempts to define this concept precisely, but the difficulty is that this concept has many dimensions. An index of biodiversity allows us to set specific goals and measure progress toward them. We will explore alternative indices of biodiversity and discuss axiomatic approaches leading to such indices. (Received September 20, 2012)

1086-AC-1272 **Suzanne Lenhart*** (lenhart@math.utk.edu), U of Tennessee, National Institute for Math. & Bio. Synthesis, and Math Dept, Knoxville, TN 37996, and **Louis Gross** (gross@nimbios.org), University of Tennessee, EEB and Math Depts., National Institute for Math & Bio Synthesis, Knoxville, TN 37996. *Infectious Disease & Sustainability: Lessons from Research at NIMBioS*.

The National Institute for Mathematical and Biological Synthesis brings together interdisciplinary teams of researchers to investigate management and spatial temporal spread patterns of infectious diseases. Such diseases can affect the sustainability of food sources and threaten global food security. The impact of zoonoses on human populations can also be significant. The variety of diseases considered by working groups and investigative workshops at NIMBioS range from John's disease in dairy cattle to pseudorabies in feral hogs. (Received September 20, 2012)

1086-AC-1301 **Steve Sain***, ssain@ucar.edu. *Quantifying Uncertainty in Climate Model Experiments*.

Climate models are large-scale, deterministic computer models that attempt to capture characteristics of the Earth's climate through simulation. There are a number of sources of uncertainty in such models, including uncertainty about initial states, parameterizations and sub-grid-scale approximations, and, of course, uncertainty about future greenhouse gas emissions and the Earth's response to those emissions. Climate scientists study

this uncertainty by running models under different conditions or by considering a collection of different models. In this talk, I will discuss one such experiment that is associated with the North American Regional Climate Change Assessment Program (NARCCAP). Focused on the multi-model ensemble of regional climate models that is at the heart of NARCCAP, I will discuss statistical methodology based on the concept of the functional analysis of variance that seeks to partition the variability in the model output and projections of climate change and attribute that variability to different sources. (Received September 20, 2012)

1086-AC-1309 **Paul R. Ehrlich*** (pre@stanford.edu). *Overpopulation: A Central Factor in the Prospective Collapse of Civilization.*

We are faced with environmental problems that threaten a collapse of civilization. These include climate disruption, biodiversity loss and resource depletion. This short list of problems reflects the interactions of two complex adaptive systems – the biosphere and our socio-economic system. The problems are getting worse, driven by overpopulation, overconsumption, and environmentally malign technologies. All of the interconnected problems are caused in part by overpopulation. Ecological footprint analysis shows that to support today's population sustainably at current levels of consumption would require roughly another half a planet; at the U.S. level, it would take four to five more Earths. Mathematicians are well-positioned to help make society more aware of the consequences of unsustainable actions, beliefs or decisions. E.g., the belief of many economists and politicians that an economy can grow at the rate of 3% per year indefinitely, as well as many everyday decisions such as how many children to have, or where to live. A central goal of the Millennium Alliance for Humanity & the Biosphere (MAHB) is mobilizing society for sustainability. By joining MAHB, mathematicians can contribute to this effort, broaden their scope, and help society steer a safer course. (Received September 21, 2012)

1086-AC-1432 **Roland Lamberson*** (rh11@humboldt.edu). *Sustainability and the Crisis in World Fisheries.*

The crisis in the fisheries of the world is largely a problem of too many boats chasing too few fish in an uncertain environment. We will examine some bio-economic models in an attempt to understand why most of our efforts at fisheries management have failed, and then suggest some new models for management that have the potential for success. (Received September 21, 2012)

1086-AC-1502 **Mary Lou Zeeman*** (mlzeeman@bowdoin.edu) and **Gene Fiorini*** (gfiorini@dimacs.rutgers.edu). *Planet Earth in the Mathematics Curriculum.*

Understanding Planet Earth has driven research in many elegant fields of mathematics and has always inspired the mathematics curriculum. Our courses have been filled with examples from physics for centuries. More recently, we have included examples from biology, medicine, economics, computer science and the social sciences. Pressing sustainability questions facing the planet are now shaping new, cross-disciplinary research questions. This is inspiring new curriculum innovations to help students develop insight into the mathematics underlying those questions. We will visit some of the Mathematics of Planet Earth curriculum materials available on the MPE 2013 website. (Received September 22, 2012)

1086-AC-1663 **Ben Fusaro*** (fusaro@math.fsu.edu). *The Malthusian Challenge – Increasing Human Demands vs Decreasing Resources.*

T.R. Malthus ("An Essay on Population", 1798) predicted the clash between limited resources and a growing population P and per capita consumption C . The PC product represents the impact on the natural biophysical system, which includes the land and minerals of his day, along with clean water, viable fisheries, stored fuels, etc. The purpose of this talk is to provide a different way to value the contributions of the natural system than is currently accepted by many politicians and economists. Their dollar-based methods overestimate and underestimate, resp., the contributions of humans and of the natural system. In a sustainable system, the PC impact (C in energy units per cap.) must not exceed the surplus energy that the natural system can provide. Also, the energy units must reflect the work done by the natural system. The concept of embodied energy (H.T. Odum, 1967) does this – one BTU of oil has more embodied energy than one BTU of wood has. Another concept that updates how to value an energy system is the Energy Return on Investment. Exactly analogous to the ROI of business, the EROIs were large for oil and the fisheries of 50 years ago. These two concepts can help gauge the worth of "green" energy systems that promise to offset falling EROIs and yield sustainability. (Received September 25, 2012)

Mathematics, Computer Graphics, and Film Production

1086-AD-251 **Ravi Ramamoorthi*** (ravir@cs.berkeley.edu). *Sparse and Multiresolution Representations of Visual Appearance.*

One of the key challenges of computer graphics is to represent and understand the visual world. The material properties of objects, from the characteristic look of a human face, to the reflections off a velvet cushion, to the translucent appearance of leaves, require new mathematical approaches to digitally model visual appearance.

The complexity of appearance is enormous, with accurate modeling needing to consider its variation across the surface from every viewing direction, and lit from any incident direction. Similar problems occur in relighting synthetic scenes, or using high-dimensional Monte Carlo rendering for image synthesis.

In this work, we show several recent examples where exploiting the sparse, lower-dimensionality, or compressibility and multiresolution nature of visual appearance can lead to dramatic improvements in computer graphics algorithms. We showcase examples from real-time rendering, offline image synthesis and appearance and light transport acquisition. (Received August 13, 2012)

1086-AD-285 **Dan B Goldman*** (dgoldman@adobe.com), Adobe, 801 N 34th St., Seattle, WA 98103. *Non-parametric image optimization.*

Patch-based methods have shown tremendous promise for solving a range of optimization problems in image and video analysis, editing, and synthesis. Until recently these methods were too costly for practical use, due to the high cost of approximate nearest-neighbor searches in high-dimensional patch space. In this talk I'll describe the PatchMatch nearest-neighbor algorithm, which accelerates these methods while using less memory than previous approaches, and several follow-on projects that utilize the same core ideas. Although our current projects revolve mostly around static image manipulation, I'll also discuss the impact these approaches may have on film and video production in the future. (Received August 15, 2012)

1086-AD-303 **Tim Chartier*** (tichartier@davidson.edu), P.O. Box 6908, Department of Mathematics, Davidson College, Davidson, NC 28035. *Animating Class with Computer Graphics.*

Mathematical material is often enhanced with connections to the real world. Computer graphics is an area that applies to such classes as Finite Math, Calculus, Linear Algebra, and Differential Equations. This talk will illustrate how computer graphics can enhance a mathematical lesson. Students can create their own Instagram effects with linear algebra and understand the role of differential equations in computer generated images. From image processing to special effects, the field of computer graphics offers a treasure chest of applications that can enhance a mathematical classroom - for the instructor and student. (Received August 17, 2012)

1086-AD-2202 **Rasmus Tamstorf***, 500 S. Buena Vista St., Burbank, CA 91521. *Plausibly unrealistic: Physical simulation in animated feature films.*

Animated feature films depend on simulating physical systems for cloth, hair, fluids, rigid objects and soft tissue. This talk will provide a brief overview of some of these and the set of mathematical challenges that they bring along. This includes the fact that all of it is purely imaginary, and therefore may not obey ordinary rules. A more practical challenge is that most of the simulations are usually so slow that they must be run offline. Especially when they involve hundreds of thousands of degrees of freedom. Yet, being able to simulate large systems interactively can improve the creative process for artists significantly. As an example of how this can be overcome we shall consider the simulation of soft tissue. For this problem we have developed a stabilized one point quadrature scheme on a hexahedral grid, which allows us to solve co-rotated linear elasticity equations using a multigrid solver in near real time for systems with up to half a million degrees of freedom. The choice of mathematical techniques here is influenced not only by the physics of the underlying problem, but also by current trends in computer architecture which demand massively parallel applications. (Received September 25, 2012)

1086-AD-2986 **Doug Roble**, Digital Domain Productions, Inc.. *Visual Effects and Fluids - The search for artistic realism.*

In the late 1990s a couple of papers came out that showed that realistic fluid simulations (both gas and liquid) were viable for visual effects in film production. Since then, there has been an explosion of research in fluid simulation for computer graphics and use of fluid simulations in film. Both academic researchers and industry engineers have been working on many aspects of improving the simulations: What is the best way to track the fluid? How fast can the simulations run? How can artists control the fluid? Is it possible to reduce or remove the numerical diffusion inherent in the simulation?

This talk will examine the recent history of fluid simulation in the visual effects industry and some significant mathematical advances that changed the way we do simulation. We will illustrate these changes with examples from various films and discuss the way fluid simulation is used by artists in production. (Received September 27, 2012)

Mathematics in Industry

1086-AE-573 **B. S. Tilley*** (tilley@wpi.edu), Dept. Mathematical Sciences, 100 Institute Road, Worcester, MA 01609, **D. W. Schwendeman** (schwed@rpi.edu), Dept. Mathematical Sciences, 110 8th St., Troy, NY 12180, **C. P. Please** (cpp@maths.soton.ac.uk), School of Mathematics, University of Southampton, Southampton, England SO17 1BJ, United Kingdom, and **F. Hendriks** (ferdi.hendriks@hgst.com), 3403 Yerba Buena Rd, San Jose, CA 95135. *A Homogenization Analysis of the Compressible Flow Between a Slider and a Moving Rough Surface.*

The compressible flow between a slider and a moving rough surface is examined asymptotically and numerical in the limit of very small gap height. The amplitude and wavelength of the roughness are assumed to be of the order of the gap height. A two-scale homogenization analysis is employed to determine a nonlinear elliptic partial differential equation governing the leading-order pressure in the gap on the scale of the slider. The equation involves coefficient functions which are determined numerically by averaging Stokes flows on the scale of the roughness. Comments and a brief analysis is given on the reduction of the governing equation for pressure in the limit of long wavelength of the surface roughness. (Received September 07, 2012)

1086-AE-984 **Todd Plantenga*** (tplante@sandia.gov). *Graph Algorithms in MapReduce to Characterize Billion-Node Power Law Networks.* Preliminary report.

Many applications in the "Big Data" world are cast as large-scale graphs, and problems are addressed with well-known graph algorithms. Graph sizes are so large that distributed storage is necessary, and algorithms must be implemented in distributed computing frameworks such as MapReduce. Most application domains, including social networks and the world-wide web, generate graphs whose vertices follow a power law degree distribution, resulting in computational bottlenecks that affect algorithm design. The talk will focus on the seemingly simple task of counting triangles in a graph. Triangles are fundamental entities in characterizing a social network, occurring when a person's friends are also friends with each other. The talk will delve into recent research on probabilistic sampling methods that scale to distributed implementations. (Received September 17, 2012)

1086-AE-1169 **Stephen P. Keeler*** (stephen.p.keeler@boeing.com), P.O. Box 3707 MC 7L-21, Seattle, WA 98124-2207. *Getting Math Off the Ground: Applied Mathematics at Boeing.*

Boeing's Applied Mathematics group works with engineers on the design and manufacture of Boeing products, conducts applied research and development, and does consulting and software development for non-Boeing customers. This talk describes the types of problems and applications we deal with and the mathematical disciplines and other skills which are important. It also deals with the special constraints that arise in an industrial setting and outlines some considerations of importance for a mathematician contemplating an industrial career. (Received September 19, 2012)

1086-AE-1952 **Erica Klampff*** (eklampf1@ford.com). *The Role of Analytics in Ford's Blueprint for Sustainability.*

Few, if any, issues are more important to Ford's future than climate change, and there is increasing recognition that environmental and business sustainability go hand-in-hand. Ford is recognized as contributing to climate stabilization by building green manufacturing facilities (Dearborn Truck Plant has the nation's largest living roof) and offering a suite of new vehicles that achieve industry leading fuel economy. What might not be as well known is that Ford's strategic sustainability efforts, as outlined in the *Blueprint for Sustainability*, are supported by analytical methodology. I will provide an overview of such modeling efforts in global energy modeling, setting internal regional CO₂ targets, meeting fleet regulatory compliance, building competitive fuel efficient platforms, and predicting consumer's willingness to pay for emerging technology. In addition, we are developing analytical tools to assist our fleet customers with their purchase decisions so that they can achieve both their sustainability and business goals. Ford is leveraging collaborative efforts with many universities to accelerate these efforts. It's not easy being green, but analytics sure help! (Received September 24, 2012)

1086-AE-2886 **Helen Moore*** (helen.moore@certara.com), 100 Mathilda Place, Suite 160, Sunnyvale, CA 94086. *Mathematics and Statistics in Drug Development*.

The Food and Drug Administration (FDA) requires extensive mathematical and statistical analysis of data before approving new drugs. Biotechnology and pharmaceutical companies use additional analysis for internal decision making. I will discuss some of the types of standard analyses of drug concentration data (pharmacokinetics) and drug effect data (pharmacodynamics). I will also mention some open questions and opportunities for new mathematical and statistical approaches to advance drug development. (Received September 26, 2012)

1086-AE-2953 **Catherine Helen O'Neil*** (cathy.oneil@gmail.com), 15 Claremont Ave, #91, New York, NY 10027. *Weapons of math destruction*. Preliminary report.

In this talk, the speaker will explain how modern mathematical modeling is used to segment and measure individuals, often to their detriment, and often in opaque and unreasonable ways. (Received September 26, 2012)

Thinking Linearly about Data in Research and Teaching

1086-AF-470 **Chuck Wessell*** (cwessell@gettysburg.edu). *Ranking Individual Sports: Lessons from Tennis and Golf*.

The linear algebra based methods developed for sports ranking are primarily used for ranking college football and basketball teams. Besides both being team sports, NCAA football and basketball are characterized by schedules where each team plays approximately the same number of games and where each team plays only a small fraction of all the teams in their NCAA Division.

This talk will address the applicability of linear algebra based ranking methods to two individual sports. Will these methods produce sensible rankings for professional tennis, where the best players play far more matches than an average ones, or for professional golf, where each round can be viewed as a head-to-head match-up between each pair of players in the tournament? If not, can some simple modifications be made to improve ranking methods for sports other than college football and basketball? (Received September 04, 2012)

1086-AF-1140 **Denise R. Koessler** (dkoessle@eecs.utk.edu), EECS Department, Min H. Kao Building, Suite 401, 1520 Middle Drive, Knoxville, TN 37996, **Michael W. Berry*** (berry@eecs.utk.edu), EECS Department, Min H. Kao Building, Suite 401, 1520 Middle Drive, Knoxville, TN 37996, and **Chris Groer** (chris.groer@linkanalytics.com), 1050 Crown Pointe Parkway, Suite 1580, Atlanta, GA 30338. *Data Forensics on Your Social Fingerprint*.

A person's social fingerprint is encapsulated in Facebook activity, mobile phone connections, email exchanges, tweets, and in other avenues of electronic socialization. Using patterns extracted from such interactions, data analysts aim to identify spammers, market trends, account movements, and sentiment. Well-studied applications in mathematics and computer science of this type of data forensics include the Netflix recommendation problem, targeted online advertising systems, and credit card fraud. In this talk we demonstrate the impact of data forensics and social fingerprinting by showcasing how one's persona can be identified by ranking the behavior between social connections. Specifically, we apply similarity measures to known social identities in order to rank trends of social behavior over time. (Received September 19, 2012)

1086-AF-1493 **Van Emden Henson*** (henson5@llnl.gov). *Spectral Methods for Finding Near-Bipartite Components in Large Scale-Free Graphs*.

Spectral transformations can be used to map the vertices in large graphs into low-dimensional spaces where important graph features can often be discovered or approximated with increased efficiency. While many common definitions assume the members of a community are more strongly connected to each other than to nonmembers, realistic communities may contain subsets of vertices with little or no possibility of direct connection; that is, they may contain bipartite or near-bipartite components. For example, a job-placement website may have many connections between applicants and potential employers but few if any connections among the applicants, who are competitors for the jobs, or among the employers, who are competitors for the applicants. Good community detection algorithms should not fail in these circumstances, which are commonly present in real-world networks.

We describe spectral-based methods for looking for strong near-bipartite communities. Specifically, we examine the spectra of common matrices used to represent graphs, particularly the combinatorial, normalized, and signless graph Laplacians. We extend theory relating the eigenpairs to clustering and bipartite components. We

describe and demonstrate algorithms that seek to identify near-bipartite components. (Received September 22, 2012)

1086-AF-1542 **Amy N. Langville*** (langvillea@cofc.edu), 175 Calhoun St-RSS 339, Charleston, SC 29401. *Ranking with Optimization Techniques.*

This talk presents a rating method that, given information on the pairwise comparisons of n items, minimizes the number of inconsistencies in the ranking of those items. The Minimum Violations Ranking (MVR) Method uses a binary linear integer program (BILP) to do this. We were able to prove conditions when the relaxed linear program (LP) gives an optimal solution to the original BILP. In addition, the LP solution gives information about ties and sensitivities in the ranking. (Received September 23, 2012)

1086-AF-1878 **Kenneth Massey*** (kmassey@cn.edu), Jefferson City, TN 37760. *Sports Ratings by Linear Regression with L^p norms.*

Regression models are often used to evaluate team strengths in competitive leagues. After exploring the nature of schedule graphs, we will describe the common least squares ($p = 2$) approach for determining team ratings, and then generalize to other norms. After building the class of models, we will consider computational algorithms, solution properties, and goodness of fit, using recent college football seasons for illustration. (Received September 24, 2012)

Where Have All the Zeros Gone?

1086-AG-535 **Stephanie Edwards*** (sedwards@hope.edu), 27 Graves Place, Department of Mathematics, Holland, MI 49423. *Extreme curvature of polynomials and level sets.* Preliminary report.

Let F be a real polynomial of degree N . Then the curvature of F is defined to be

$$\kappa = \frac{F''}{(1 + (F')^2)^{\frac{3}{2}}}.$$

Determining the maximum number of zeros of κ is an easy problem: since the zeros of κ are the zeros of F'' , the curvature of F is 0 at most $N - 2$ times. A much more intriguing problem is to determine the maximum number of relative extreme values for the function κ , or equivalently, determine the maximum number of zeros of κ' . In 2004 it was shown that if all the zeros of F'' are real, then F has at most $N - 1$ points of extreme curvature. We use level sets and auxiliary functions to study the zeros of the derivatives of these functions. We provide a partial solution to this problem, showing that F has at most $N - 1$ points of extreme curvature when F has only simple zeros and when certain geometrical conditions hold. (Received September 06, 2012)

1086-AG-598 **Jessalyn Bolkema*** (jessalyn.bolkema@huskers.unl.edu). *Non-real zeros of derivatives of a class of real entire functions.* Preliminary report.

In 1943, G. Polya conjectured that the number of non-real zeros of the k th derivative of a real entire function of order greater than 2, with finitely many non-real zeros, tends to infinity as $k \rightarrow \infty$. This was verified in 2005 by A. Eremenko and W. Bergweiler. A natural extension is whether the number of non-real zeros of the k th derivative increases monotonically as $k \rightarrow \infty$. We show that the number of non-real zeros of $f^{(k)}(z)$ increases monotonically with differentiation when $f(z) = z^m e^{K(z)}$ where $m \in \mathbb{N}$ and K is in one of several special classes of real polynomials. (Received September 08, 2012)

1086-AG-1317 **Matt Boelkins*** (boelkinm@gvsu.edu). *Where the Critical Numbers of a Polynomial Aren't.*

For a real polynomial with all real zeros, Rolle's Theorem guarantees that between each pair of zeros, at least one critical number exists; in the situation where a polynomial has complex roots, the Gauss-Lucas Theorem tells us that the critical numbers all lie within the complex hull of the zeros. But within these regions where the critical numbers must lie, are there locations where the critical numbers cannot be?

In this talk, we will survey recent results that answer this question completely for polynomials with all real zeros, as well as complex polynomials of degree 3. For context and intuition, we'll consider several related results and ideas that exemplify the overarching theme that a polynomial's critical numbers are implicit functions of its roots. (Received September 21, 2012)

1086-AG-2036 **Jim Haglund*** (jhaglund@math.upenn.edu). *The Zeros of Eulerian polynomials and their Multivariate Extensions.*

Eulerian polynomials are the generating function of descents over permutations. They are a canonical example of a sequence of polynomials in combinatorics having only real zeros. In this talk we discuss various extensions of this result, including a multivariate Eulerian polynomial arising from the study of permanents which is stable in the sense of Brändén and Borcea. (Received September 24, 2012)

1086-AG-2923 **Alexander Vandenberg-Rodes*** (vandenbe@math.uci.edu). *The Lee-Yang Theorem in probability and statistical physics.*

First proved for the Ising model of magnetization, the Lee-Yang Circle Theorem is a remarkable result on the location of zeros of the partition (generating) function, and is the starting point for a large body of research into the nature of phase transitions in many models of statistical physics.

In this talk we will give a brief overview of the Lee-Yang theory, especially as expressed in the recent mathematical framework of J. Borcea and P. Brändén that is rooted in the following question: Which linear transformations of polynomials preserve the property that a certain subset of the complex plane is devoid of zeros?

Keeping to a more probabilistic viewpoint, we will also show how such knowledge about the zeros translates into Gaussian limit theorems for sums of even very dependent random variables. (Received September 26, 2012)

Writing, Talking, and Sharing Mathematics

1086-AH-463 **Frank Morgan*** (frank.morgan@williams.edu). *My Huffington Post Blog.* Preliminary report.

Since March I've been a Huffington Post blogger. I'll tell you what I write about: the Willmore Conjecture, tilings, Alan Alda, why summer comes so early, "Why a Laptop is Not a Computer." I'll talk about what it takes to write a blog like this, the secrets of pictures and videos, and the crazy feedback from the readers. (Received September 03, 2012)

1086-AH-1058 **Gerald B. Folland*** (folland@uw.edu). *Mathematics, Meaning, and Misunderstanding.* Mathematicians develop habits of thought and employ ways of expressing their ideas that are not always shared by others who wish to learn mathematics or use mathematics in their own disciplines. We shall comment on various aspects of this phenomenon and the (often amusing) pitfalls it creates for effective communication. (Received September 18, 2012)

1086-AH-2363 **Frank A. Farris*** (ffarris@scu.edu), 500 El Camino Real, Santa Clara University, Santa Clara, CA 95053. *Can an Art Show Teach Mathematics?*

During fall quarter 2012, Carleton College presented an exhibition of my mathematical art called "Seeing Symmetry." The show represents my best effort to communicate mathematical concepts of symmetry to the general public, and at the same time to promote the joy and wonder of mathematics. I will show representative images and explain how I think they serve to teach viewers about symmetry groups and Fourier series. The process of working with Carleton faculty and staff to develop the show, as well as watching the public view the art, increased my understanding of the question in the title. (Received September 25, 2012)

1086-AH-2368 **Barry Cipra*** (bcipra@rconnect.com). *First Things First: The Art of the Opening.* In expository writing, if you don't get the "lede" paragraph right, only the most determined readers will slog on. I'll show a few examples where it's done right, and a few where it's done wrong. If I'm last on the program, I'll critique the previous speakers' openings. (Received September 25, 2012)

1086-AH-2481 **Dana Mackenzie*** (qxpch@yahoo.com), 1165 Whitewater Cove, Santa Cruz, CA 95062. *Exposing and Expositing Math to the Public: Two Paths.*

I will describe briefly the path that led me from being a mathematics teacher and researcher to becoming a mathematics writer. I will argue that there are two paths for accomplishing this transition, and neither is for the faint-hearted. Path 1 is to cut your strings with academia and establish yourself as a journalist, first and foremost. This means writing for newspapers, magazines, TV, or radio. Probably there is nothing the math profession can or should do to make this path easier. However, there could be more discussion of this career path in graduate school, particularly for students who are disenchanted with academia. Path 2 is to stay in academia, get tenure, and then establish yourself as an authority by writing popular books. This path could be facilitated by establishing more explicit rewards for math exposition. Ideally, it should become feasible even for non-tenured mathematicians. Whether you choose Path 1 or Path 2, good writing is good writing. There are

certain bad habits of academic writing that you will need to break, and some major attitude adjustments that you will need to make if you want to succeed as a popular writer. (Received September 25, 2012)

Actuarial Education

1086-B1-165 **Mark A Mills*** (millsm@central.edu), 812 University, Campus Box 06, Pella, IA 50219. *Starting an Actuarial Science Major at a Liberal Arts College.*

After working with students who were interested to enter the actuarial career field, it became apparent to me (and many of my colleagues in the business department) that Central College needed an actuarial science major to ensure these students would be properly prepared for the career. After a lot of work to research it, design it, and get it approved, the actuarial science major at Central College became an official major in Fall 2009. This talk will address the issues related to starting an actuarial science major at a liberal arts college, as well as discussing the on-going development of a major that is only 3+ years old. (Received August 01, 2012)

1086-B1-279 **Thomas P Wakefield*** (tpwakefield@ysu.edu), Department of Mathematics and Statistics, Youngstown State University, One University Plaza, Youngstown, OH 44512. *Structuring an Exam P Prep Course.*

In this presentation, we will discuss teaching techniques, strategies, and curriculum for an Exam P prep course that serves as an introduction to actuarial science at Youngstown State. The challenges of such a course and ideas for future sections of the course will also be described. (Received August 15, 2012)

1086-B1-644 **Kevin E. Charlwood*** (kevin.charlwood@washburn.edu), 1700 SW College Avenue, Department of Mathematics & Statistics, Washburn University, Topeka, KS 66621. *An Advanced Undergraduate Actuarial Science Program at One Four-year Comprehensive University.* Preliminary report.

We shall discuss the salient features of the actuarial science program at Washburn University. This includes the specifics of the core curriculum consisting of mathematics, statistics and business courses required for our program. We also discuss the desired computing background for our program, along with local internships available to our actuarial students. Finally, we also indicate how we have responded to SOA exam series changes, over the 20 years of our program's existence. (Received September 10, 2012)

1086-B1-839 **William M. Kinney*** (bkinney@bethel.edu), Bethel University, 3900 Bethel Drive, P.O. Box 95, St. Paul, MN 55112, and **Jake Smith** (jss35646@bethel.edu). *An Example of Student/Faculty Summer Research in Actuarial Mathematics: Using Mathematica to do Demographic Modeling and the Surprising Relevance of Hypergeometric Functions.* Preliminary report.

In anticipation of eventually building an emphasis on actuarial mathematics into the mathematics major at Bethel University, during the summer of 2012, we started learning about actuarial mathematics by exploring basic demographic models and tweaking them. *Mathematica* was a very valuable tool for this exploration that allowed us to consider the behavior of life expectancy functions under nonstandard assumptions about the force of mortality. Models explored included one where the force of mortality was assumed to be periodic and another where the force of mortality was assumed to be the sum of a periodic term and a Makeham term. *Mathematica* provided us with very nice ways to approximate life expectancy functions, visualize the effects of changes in parameters, and simulate sampling from the resulting survival distributions. We also were surprised to find that a sinusoidal force of mortality with a single frequency was sufficient to generate a life expectancy function whose description required the use of hypergeometric functions. Demonstration of the relevant *Mathematica* code and an explanation of how hypergeometric functions arise in these models will be given. (Received September 13, 2012)

1086-B1-917 **Len Asimow***, asimow@rmu.edu, and **David Hudak**. *Raising Actuaries For Fun And Profit.*

This paper is about nurturing prospective actuaries from their nascent stages as high-school seniors or college freshmen, until their maturation into full-time workers at insurance companies or consulting firms. Much like cultivating orchids, the raising of actuaries requires a certain investment of time, caring and expertise. But any math or stat professor can do it, and watching your students blossom will be richly rewarding.

The presentation will cover all aspects of starting an actuarial program, from recruitment to exam preparation through job placement. Among the topics covered:

•When and how to prepare students for the first several actuarial exams, •How to enlist the support of key institutional offices, including your colleagues and academic administrators, enrollment and financial aid, marketing, public relations, career services and alumni offices, •Employer network building, •Making use of professional organizations such as the SOA, CAS and others.

The demand for actuaries remains strong, and if you choose to broaden your involvement in actuarial education it should prove a benefit to you, your students, your school and the actuarial profession. (Received September 16, 2012)

1086-B1-968 **Paul T Taylor*** (pttaylor@ship.edu), Department of Mathematics, 1871 Old Main Drive, Shippensburg, PA 17257-2299. *Starting an actuarial program without creating new courses.*

In 2006, the Department of Mathematics at Shippensburg University wanted to offer a path for students interested in becoming an actuary. Unfortunately the number of students both interested and capable of undertaking this challenging career path was quite small. The limited audience did not justify the creation of new courses. This talk will discuss what was done at Shippensburg University and explore some of the challenges and options when resources are limited. (Received September 17, 2012)

1086-B1-1159 **Barbara A Wainwright*** (bawainwright@salisbury.edu), Salisbury, MD 21801. *An Actuarial Science Program at Salisbury University.* Preliminary report.

This paper will focus on the development of an actuarial track for the mathematics major at Salisbury University. The discussion will include the timeline from the initial investigation into such a program through the proposal and approval processes. In addition, a checklist of the required courses as well as the description of new courses that had to be developed, will be provided. Salisbury University had the great fortune to hire an expert in the field who developed the new courses and worked with the speaker in the development of this actuarial science track. The speaker will also discuss to what extent the program prepares students for taking the actuarial exams and/or finding employment. Faculty from universities that are considering such a track will no doubt find this information useful. (Received September 19, 2012)

1086-B1-1370 **Mark Matthew Maxwell*** (maxwell@math.utexas.edu), 2511 Speedway Stop C1200, Austin, TX 78712. *The M349P Project: Motivating students to take responsibility and improve communication ability while studying for C/4.*

The core values of the University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. These values shaped an experiment called “The M349P Project”. During the fall 2012 semester, 47 students and I set out to learn the content of the C/4 – Construction and Evaluation of Actuarial Models, develop personal responsibility, and effectively communicate ideas to peers.

We will describe our project, discuss successes and failures, and provide resources including some of the work created from our group. Most of our ideas can be applied to any mathematics or actuarial course. (Received September 21, 2012)

1086-B1-1862 **Robert E. Buck*** (robert.buck@sru.edu), Department of Mathematics, Slippery Rock University, Slippery Rock, PA 16057, and **Richard J. Marchand.** *Building an Actuarial Science Option for Mathematics Majors.*

Actuarial Science is an attractive career for mathematics majors; however, most small and mid-sized departments lack the resources to offer an advanced program in this area. At Slippery Rock University, we started an actuarial Special Interest Area in 1989 by organizing courses that we already had and expanded our offerings as student interest grew. We will discuss the help that is available when starting an actuarial program and the steps that we took and continue to take to build and maintain our program. Over the past 25 years, SRU has repeatedly adjusted to the changing SOA/CAS requirements and has been successful in placing many SRU graduates in actuarial positions across the country. (Received September 24, 2012)

1086-B1-2507 **Richard J. Marchand*** (richard.marchand@sru.edu), Department of Mathematics, 200M Vincent Science Center, Slippery Rock University, Slippery Rock, PA 16057. *Preparing Students for Exam FM.* Preliminary report.

A crucial element of any successful actuarial program is an effective plan for preparing students to pass the examinations, especially when resources are very limited. The purpose of this talk is to discuss strategies employed at Slippery Rock University to increase the likelihood of success for our students who are taking Exam FM. We will discuss details involving both our Theory of Interest course and the accompanying Exam FM Prep course along with our constantly evolving plan for preparing students to take Exam FM. (Received September 25, 2012)

Adding Modern Ideas to an Introductory Statistics Course

1086-B5-55 **Jeff Suzuki*** (jeff_suzuki@yahoo.com), 235 South Riverside Road, Highland, NY 12528.
Fisher's Test and the Ubiquity of Small Samples.

When considering the problem of whether or not discrimination has occurred, the legal system often relies on a truism that statistics cannot be applied to small samples. But statistical tests on small samples do exist, and by ignoring them, the court risks permitting gross injustices. Fisher's Exact Test is both simple and easy to do "by hand," but most introductory statistics courses give it scant, if any, attention. We present examples where Fisher's Exact Test could have been applied in civil and criminal cases, and argue that the courtroom context may be the best way to introduce the notion of statistical significance. (Received June 23, 2012)

1086-B5-106 **Joe DeMaio*** (jdemai@kennesaw.edu) and **Amy Hillen** (ahillen@kennesaw.edu).
Incorporating Real Data Sets and Writing into an Introductory Statistics Course Focused on Sports and Games.

The ability to reason statistically is critical to becoming an informed citizen and intelligent consumer (Aliaga, et al., 2010). Despite its importance, research indicates that students struggle to reason statistically and that students typically enter introductory statistics courses "under sufferance, with levels of resistance related to their beliefs of the relevance of statistics" (Howley, 2008).

One approach for helping students make sense of complex mathematical ideas is to situate the ideas in real-world contexts that have meaning for students. We contend that the context of sports and games might be particularly promising, because: 1) it is a rich site for studying statistical ideas (e.g., probabilities in card and board games; correlation of player and/or team statistics); and 2) it is likely of interest to a wide range of students.

In this talk, we describe writing assignments that use real data sets in a general education elementary statistics course focused on sports and games, and discuss student reflections on the efficacy of such assignments. (Received July 19, 2012)

1086-B5-433 **Sue B. Schou*** (schosue@isu.edu). *Using The Island for Student Projects.*

Have you ever wanted to have your students gather real data from real participants? Currently, this is almost impossible in a one term course due to constraints for protecting human subjects. The Island is an online environment populated with islanders' profiles, family history, location, and other pertinent information at the islander level, all designed by the programmers. Consequently, students can design an experiment and gather "real" data from "real" participants. This digital environment is programmed with more than 50 questions that the student can choose from to query an islander as well as more than 200 possible actions that the islander can be requested to do. This presentation will discuss the environment in detail and show examples of student work. Not only is this a wonderful experience for introductory students but it can be used at all levels and in a variety of majors. (Received September 01, 2012)

1086-B5-619 **Robert P. Webber*** (webber@longwood.edu), Math and Computer Science Department, Longwood University, Farmville, VA 23909. *The New York Stock Exchange: A Real World Data Set.*

This paper discusses the use of the set of stocks on the New York Stock Exchange (NYSE) as a large data set in an introductory statistics course. It grew out of an assignment in which students were asked to do some statistical analysis on the set of NYSE stocks based on a random sample. Advantages of using this data set include its time sensitive nature, practical appeal, and the need for a random sample to draw inferences about it. Finding a random sample produces some interesting problems, such as the lack of uniformity in different sources for the stocks listed and the forms in which the listings are commonly given. A spreadsheet is invaluable in obtaining and analyzing the sample. This data set provides an opportunity for students to take random samples of real world data and to experience some of the problems and frustrations involved. Relevant web sources are given. (Received September 09, 2012)

1086-B5-650 **Joseph P McCollum*** (jmccollum@siena.edu), Siena College, School of Business, 515 Loudon Road, Loudonville, NY 12211, and **Arindam Mandal**. *Seasonality and Autocorrelation: The typical "problem" children in business statistics.* Preliminary report.

In business statistic classes when you talk about economic data, for example consumer confidence or unemployment rates, you will typically meet with the issues of seasonality and autocorrelation. We believe by using hands on data the students get a better feel for these abstract ideas and hopefully a better appreciation for the pitfalls that come with using linear regression and time series. In our presentation we will look at an unemployment

data set collected from the Bureau of Labor Statistics and data collected on consumer confidence from the Siena Research Institute. We believe with a perfectly picked data set the topic of time series can be more understandable for entry level statistic classes. We would like to show this data set and talk about some of the many real world obstacles that face business students when it comes to analyzing statistical data. (Received September 10, 2012)

1086-B5-730 **Stephen D. Szydlik*** (szydliks@uwosh.edu), Math Department, UW Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54901, and **Jennifer E. Szydlik**. *Real Data, Real Stakes: Introductory Statistics Students Predict the Wisconsin Recall Election.*

For two months in spring 2012, Wisconsin's Government Accountability Board (GAB) labored over 152,335 Recall Petitions, checking each entry to determine whether there were enough valid signatures to trigger a recall election of Governor Scott Walker. Meanwhile, students in a class for future elementary teachers used statistical sampling to do the same job in just one week using open-source software. We will report on this powerful project in which introductory statistics students not only predicted the total number of signatures and verified that a recall election would be held, but also became convinced of the power of sampling and went to press with their results. (Received September 11, 2012)

1086-B5-852 **Penelope H. Dunham*** (pdunham@muhlenberg.edu). *All the Statistics That's Fit to Print.*

How do we prepare today's introductory statistics students for a lifetime of consuming statistical information as reported in the media? Most of our students will never produce statistical studies or do hypothesis tests after they leave our classes. Some may see statistical analyses in a major course, and a few (in biology or psychology) may use statistics in their own research. All, however, will encounter statistics when they hear or read abbreviated media reports of polling outcomes, medical trials, surveys, and other studies. As informed citizens, they will need skills to interpret statistical reports critically. Developing those skills is one of the challenges for teachers of a modern statistics course. In this talk, I describe a set of activities to help students become critical consumers of media reports of studies. The activities combine classroom discussion with reading and writing assignments. Using a version of De Veau, Velleman, and Bock's "Six W" questions (Who, What, When, etc.), students analyze newspaper articles to determine a study's design, population, statistical analysis, outcomes, and conclusions. Activities include library assignments, comparisons of reports from different media, and a contrast of a media report with a journal article. (Received September 14, 2012)

1086-B5-1322 **Dianna J. Spence***, North Georgia College & State University, Dep't. of Mathematics and Computer Science, 82 College Circle, Dahlonega, GA 30597, and **Sherry L. Hix**, North Georgia College & State University. *Combining Strategies to Promote Meaningful Learning in Statistics.*

We share a blend of three strategies to help students develop both a deeper understanding of statistical concepts and an awareness of the relevance and application of statistics in their lives. The first strategy is the simulation of repeated trials to explore statistical reasoning and the context for hypothesis tests. Simulations are conducted both with concrete materials and with readily available web-based applets. The second strategy is to facilitate student-directed projects in which students identify their own variables and research question, collect and analyze their own data, and formally report their findings. The third strategy is to use collaborative groups to discuss, analyze, and critique published articles that report findings of statistical studies, attending to specific aspects of the study, such as sampling, data collection methods, statistical analysis, and interpretation of results. Examples, sample materials, and resources used to employ each strategy are shared.

The connections and interplay among these three strategies are also discussed. Because each strategy helps to illuminate or strengthen some aspect of the other two, the contribution to student learning achieved by combining the strategies is greater than the sum of its parts. (Received September 21, 2012)

1086-B5-1555 **Michael A. Posner*** (michael.posner@villanova.edu). *A Hybrid of Online Assessment and Graded Homework: The Challenges and Impacts on Student Engagement and Learning.*

How do we get our students to learn? According to Lovett and Greenhouse in their article "Applying Cognitive Theory to Statistics Instruction," we need to do a better job of allowing students to practice the techniques from the classroom ('time on task') and to provide real-time feedback as they solve problems. Mastery-based learning, competency- or standards-based grading, and proficiency-based assessment and reassessment of learning outcomes (PARLO) systems all require repeated assessments of material with feedback to foster student learning. Active learning techniques and flipped classrooms address this problem, but most of us cannot transform to such

a model in one semester, let alone (it sometimes feels like) in one career. How can you achieve these goals with the competing demands on our time, be they other courses, research papers, or family life?

I have experimented with a hybrid system of online, algorithmically generated problems where students are allowed to resubmit as many times as they want along with 1-2 open ended problems that require higher order comprehension. I will share the technological challenges of employing such a system as well as the findings from this classroom study. (Received September 23, 2012)

1086-B5-1583 **Khairul Islam*** (mislam4@emich.edu), Department of Mathematics, Eastern Michigan University, Ypsilanti, MI. *Technology in Achieving Course Objectives in an Introductory Statistics Course.*

Students taking introductory statistics course usually come from multidisciplinary areas with very little mathematical background and computational abilities. The objective of introductory statistic course is mainly the conceptual understanding of basic statistical techniques and interpretational ability of analytic results. Under these circumstances, examples and activities that reflect real-life applications and the use of an appropriate technology help achieve the course objectives efficiently. In this talk, I will present examples and approaches I found useful while teaching introductory statistics course for more than a dozen of times in face-to-face and hybrid setup. A particular attention will be given on the feasibility of teaching introductory statistics course using large data set by means of a Graphing Calculator, Excel and an open source software R. (Received September 23, 2012)

1086-B5-1755 **Iwan Praton*** (ipraton@fandm.edu). *Teaching using the Lock-5 book.* Preliminary report. I will describe my experience teaching introductory statistics using the Lock-5 book, which emphasizes bootstrapping and randomization. Overall, it worked quite well, but I will concentrate on some of my mistakes, including pacing, the use of computers, and writing appropriate exam questions. (Received September 24, 2012)

1086-B5-1829 **K.L.D. Gunawardena*** (gunaward@uwosh.edu), Department of Mathematics, University of Wisconsin Oshkosh, Oshkosh, WI 54901-8631. *Use of data sets and projects in an Applied Statistics course.*

Math 201 Applied Statistics is a course taken by students in many majors including biology, nursing, computer science, chemistry, and kinesiology. Because of the diverse background of students in the course real data sets and projects that are of interest to students need to be used in the course. In this presentation I will provide some data sets used in the course and projects done by students. (Received September 24, 2012)

1086-B5-1975 **Debra Hydorn*** (dhydorn@umw.edu), University of Mary Washington, 1301 College Avenue, Fredericksburg, VA 22401. *Using R for Data Analysis Assignments in an Introductory Statistics Course.*

Instructors have many choices for meeting the ASA's Guidelines for Assessment and Instruction in Statistics Education (GAISE) recommendation to use technology for analyzing data in the introductory statistics course. I have tried several options, including requiring that students use licensed software (SPSS) in a campus computer lab. With most students coming to college with their own computers, I decided to consider options that students could use off campus. I attended a workshop where R was introduced and its use in the introductory course was discussed. After two semesters of using R for class assignments I have found that, while students are no longer required to go to an on-campus computer lab to complete their assignments, their understanding of how their computer works can pose problems with using R. In this talk I will describe a few of the problems that have occurred with using R in my introductory statistics course and my solutions to those problems. (Received September 24, 2012)

1086-B5-2065 **Judith Canner*** (jcanner@csusb.edu), 100 Campus Center, Seaside, CA 93955, and **Jon Detka.** *Teaching Introductory Statistics Concepts using Resampling Methods in R.*

The use of R programming in an undergraduate Statistics course is becoming more common. There is also a movement to incorporate resampling and randomization methods into Statistics courses as a method to help students gain a deeper understanding of difficult concepts. The success of incorporating R programming into an undergraduate Applied Statistics course at California State University, Monterey Bay has motivated us to incorporate resampling techniques using R into the course curriculum as well. We will discuss our approach to designing lecture materials in conjunction with in-class activities and lab assignments to demonstrate basic concepts of Statistics using resampling. These concepts include sampling distributions, confidence intervals and hypothesis testing. We will discuss different approaches to teaching and structuring resampling methods in R as well as how these methods shape a student's understanding of basic Statistics concepts. Activity and assignment

examples will be demonstrated and discussed within the context of an Applied Statistics course with a Calculus I pre-requisite. (Received September 24, 2012)

1086-B5-2338 **Patricia B Humphrey*** (phumphre@georgiasouthern.edu), Department of Mathematical Sciences, PO Box 8093, Statesboro, GA 30460-8093. *Simulation Illogic Repaired.*

Simulations are becoming more important in introductory statistics courses because of new emphasis on re-sampling procedures (which are now included in the Common Core for high school students). There are many applets (and apps) that will perform simple simulations and resampling. Do students really understand what is being done in the (often) black box? In many cases, the answer is "No." For example, students thinking about a bootstrap confidence interval for a mean often ignore the paired nature of the data and want to randomly permute only one of the variables. More complex simulations require more thinking and capable software. At an introductory level for a probability or statistics class, R (free) or SAS (expensive) are often too complex for students to use effectively. I'll show how simple three or four line execs and macros in Minitab can do the job effectively, and further serve to eliminate the "black box" of many applets. Students who can perform these understand the situation! (Received September 25, 2012)

1086-B5-2376 **Kari Lock Morgan***, kari@stat.duke.edu. *Simulating with StatKey.*

StatKey (www.lock5stat.com/StatKey) is free online technology created by the Lock family for use in introductory statistics courses. This easy to use technology that works in all common web browsers utilizes simulations to help students understand key concepts of statistical inference. It is particularly designed to help students understand and implement bootstrap confidence intervals and randomization tests, although is also useful in a more traditional course for illustrating descriptive statistics, sampling distributions, confidence intervals, simple linear regression, and as a replacement for the distributional tables found in the back of many textbooks. In this talk we'll demo StatKey, and discuss its use in introductory statistics courses. (Received September 25, 2012)

1086-B5-2482 **Jeff Randell Knisley*** (knisleyj@etsu.edu), Box 70663, Department of Mathematics and Stat, East Tennessee State University, Johnson City, TN 37614-0663. *Adventures in Statistics: Encounters with Big Data.*

Many modern statistical applications involve complex data sets that are not only large but that also have features not found in smaller data sets (local outliers, for example), and quite often, these large complex data sets occur in applications that students can readily understand (questions about social networks, for example). Technology allows students to be equipped with some basic tools with which they can explore these large data sets, and given the choice, they often prefer such tools over other approaches to data analysis. Specifically, we have found that students from middle school and up tend to choose bootstrapping or similar resampling methods when given the choice (as is the case in summer programs and end-of-semester projects for introductory courses). In this presentation, we present some simple tools in Netlogo, R, and Python that can be used to explore big data sets, after which we demonstrate some highly accessible applications which feature large data sets. We will also demonstrate how students can (and do) use these tools to explore, investigate, and infer results. We will also provide the code and data sets for download for anyone who is interested in using them. (Received September 25, 2012)

1086-B5-2490 **Derek Habermas*** (habermas@potsdam.edu) and **Cheryl Chute Miller** (millercc@potsdam.edu). *Projects to Engage Students in Introductory Statistics.* Preliminary report.

We present a series of projects that we have developed for students, who are generally not mathematics or statistics majors, in an introductory statistics course. The main goals are to increase student engagement and help students interpret statistical statements in proper context. In the projects described, the students use the same data set, which they have collected themselves, for data description, probability, confidence intervals, and hypothesis testing. We will discuss implementation, evaluation, and student feedback. (Received September 25, 2012)

1086-B5-2665 **Chris Oehrlein*** (cdoehrlein@gmail.com), 1320 SW 122nd St, Oklahoma City, OK 73170. *Journals and Wikis in Hybrid and Online Intro Statistics.*

Introductory Statistics courses are equal parts mathematics, social science, logic and critical thinking. Students and instructors in the past have had to spend a lot of time on developing the mathematical side of the course, expending a lot of effort and energy on formulas and computations. While the other aspects of the course existed, they tended not to be highlighted, but instead given token attention. The only real aspect of logic would have been how to use a p-value to make a conclusion about a null hypothesis, but still without a lot of time spent (or

available to spend) on the logic of why the different decisions were made. Modern introductory statistics courses that should be using more hands-on experiences and technology to help students see, feel and understand the underlying principles of variability, inference, design, etc. lend themselves to asking students to reflect on how all of this conceptual knowledge can be applied. Instructors should give students opportunities to write more about what they are learning and how to apply that knowledge. The presenter will share writing assignments, how he uses electronic media to encourage collaboration and improve feedback in hybrid and online courses, and ideas about grading rubrics for writing in statistics. (Received September 25, 2012)

1086-B5-2705 **William H Rybolt*** (rybolt@babson.edu), M/S, 231 Forest St., Babson College, Babson Park, MA 02457, and **John D McKenzie**. *Introducing Big Data in an Introductory Applied Statistics Course.*

Mathematics, Statistics, and the Data Deluge, the theme of the 2012 Math Awareness Month, reflects that massive amounts of data are now available on the Internet. Big Data is characterized by its three Vs: volume, velocity, and variety. It is not uncommon for a dataset to have more than a terabyte of data. Even more striking is that our social networking activities, on-line searches, financial transactions, and weather satellites may generate more than a terabyte of data each day. What compounds the problem of dealing with such data is its lack of structure. For example, an Internet query is usually a combination of numbers, text, dates, times, pictures, and hyperlinks. These data by their very nature are often messy and redundant. We identify several large datasets and use software, such as Minitab and Excel, to illustrate some of the complications with analyzing Big Data. Common descriptive and inferential methods which work so well with small, clean, well-structured data often fail when used on these datasets. We introduce ways of exposing students to Big Data in a first course. As two examples, asking them to work with data that exists in a form other than a spreadsheet of numeric values with no missing data and spending more time on various visualization techniques. (Received September 25, 2012)

1086-B5-2828 **Patti Frazer Lock*** (plock@stlawu.edu), Dept of Math, CS, and Stats, St. Lawrence University, Canton, NY 13617, and **Robin H. Lock** (rlock@stlawu.edu), Dept of Math, CS, and Stats, St. Lawrence University, Canton, NY 13617. *A Fiddler on the Roof: Tradition vs Modern Methods in Teaching Inference.*

For many years, we have taught the logic of traditional inference using approximations based on normal and t-distributions. Now that the necessary computing power is readily available, some people are suggesting using modern resampling methods as a more intuitive way to introduce the concepts of statistical inference. Should we stick with familiar traditions, embrace a new approach, or find a way to use the best of both? The speakers will debate the merits of these options. (Received September 25, 2012)

1086-B5-2926 **Randall Pruim*** (rpruim@calvin.edu). *The Other Intro Course: Combining Foundations, Applications, and Computation in the Math Stat Course.*

Why should non-majors get all the good stuff? A data-centered approach that uses modern computational tools (like R) and real data sets can (and should) be used when teaching our majors and minors too. This talk will explore what a modern treatment of probability and statistics can look like, starting by blurring the boundaries between the probability course and the mathematical statistics course. (Received September 26, 2012)

1086-B5-2927 **Randall Pruim*** (rpruim@calvin.edu), **Daniel Kaplan** and **Nicholas J Horton**. *A mosaic sampler: Using R and RStudio in the Intro Course with the mosaic package.*

One activity of the NSF-funded Project MOSAIC has been the production of the mosaic package (available on CRAN). This package helps provide a consistent interface to the most important computational tasks for the Intro Course and simplifies some tasks that would otherwise be too daunting for beginners (including resampling). This talk will give an overview of the principles that guided the construction of the package and a sampler of applications based on the authors' experiences using RStudio in the Intro Course. (Received September 26, 2012)

Assessing the Effectiveness of Online Homework

1086-C1-647 **Jennifer S. Hegeman*** (hegeman@missouriwestern.edu), 4525 Downs Drive, St. Joseph, MO 64507. *Student Learning Outcomes in General Studies Mathematics: A Comparison of Online and Face-to-Face.*

Online general studies math courses are becoming more common, in part due to the development of text-based, interactive multimedia tools that provide comprehensive online course materials. This study compared student learning outcomes in online offerings of college algebra with student learning outcomes in face-to-face

offerings at an open-enrollment university over a two-year period. Students enrolled in face-to-face sections consistently performed statistically significantly better than students enrolled in online sections on handwritten exams. A closer examination of handwritten student responses to a typical college algebra problem indicated that significantly more online students were unable to demonstrate a minimal level of algebraic understanding and frequently included a multitude of serious mathematics errors in their attempted solutions. Furthermore, solution methods attempted by online students varied greatly in comparison to solution methods attempted by face-to-face students. Although it is tempting to believe that comprehensive, text-based course management systems are the answer to the administrative push for more online courses, educators using one of these systems in online freshman-level math courses should not assume that students will be successful. (Received September 10, 2012)

1086-C1-920 **Anneke Bart*** (barta@slu.edu), Dept of Mathematics and Compu, 220 N Grand Blvd; Ritter Hall 115, St Louis, MO, 63103, St Louis, MO 63103. *A preliminary report on using WeBWorK in assessment of student learning outcomes.* Preliminary report.

Preliminary results show that WeBWorK grades show a fairly strong correlation with the course grades in Calculus. Using the grades on specific topics should then be an acceptable measure of student learning outcomes. An overview of the proposed assessment techniques and their results will be presented in this presentation. (Received September 16, 2012)

1086-C1-1590 **Lisa Townsley*** (townsley@math.uga.edu), University of Georgia Dept of Mathematics, Athens, GA 30602. *Using WebAssign for Homework and Testing in Precalculus: Assessment of Student Performance.*

One way to see how well students use their online homework as a learning tool is to test in the same online environment. At UGA, some 2200 students each year take precalculus, and all homework and tests are conducted online via WebAssign. The WebAssign platform provides some innovative methods to determine how long students are working on particular problems, and what previous attempts they have made. The department recently made pre-and-post-test measures of student preparedness for calculus, and are pleased with the results. An added bonus to using uniform assessment throughout the 40-seat precalculus sections is the ability to provide oversight to graduate students in their first teaching experience, and also assess their effectiveness. (Received September 23, 2012)

1086-C1-1625 **Giorgi Shonia*** (shonia@ohio.edu), 1570 Granville Pike, Lancaster, OH 43130-1097. *Integrating eText in online assessment platforms.*

One recent trend in online learning has been integration of eBook with online assessment platform. Present survey researches solutions available currently in higher education and reports on recent plans to extend such features to free and open platform. Various eBook features are examined and options of their integration with assessment explored. We also compile field experience based on student interviews about effectiveness of such assessment – eText integration. (Received September 23, 2012)

1086-C1-1798 **Rodica Cazacu*** (rodica.cazacu@gcsu.edu), Georgia College, Department of Mathematics, CBX 17, Milledgeville, GA 31061. *Using Online Homework to Track Students' Progress.* Preliminary report.

Mathematics is one of the subjects that demand a great deal of practice and each instructor wants his/her students to do that as much as possible. The homework assignments are, more or less, a tradition, especially in mathematics classes. While it is easier to grade or at least check these assignments for a small class it becomes extremely hard for large classes. That is the main reason I decided to introduce the online homework assignment in most of the introductory level mathematics classes I teach. In this presentation I will talk about how and why I introduced the online homework assignments, how I use this tool to track my students' progress in class and help them prepare for their tests, and what impact the online assignments had on my students' learning. (Received September 24, 2012)

1086-C1-1988 **Dianna J. Spence***, North Georgia College & State University, Dep't. of Mathematics and Computer Science, Dahlonega, GA 30597, and **Sherry L. Hix**, North Georgia College & State University. *Leveraging Features of Online Homework and Measuring Student Performance.*

Several features and types of assignments are available in the Portal online homework systems (e.g., StatsPortal, CalcPortal). These include algorithmic questions, question pools, and "Learning Curve" activities linked with assigned reading passages. There are also many ways to use online homework, by varying the weight of assignments in determination of grades (low to high stakes), and by varying assignment configurations, such as time

limits, number of retries allowed, and question delivery. We describe several implementations and note the role and advantages of each. We then share results of research conducted in which student performance on online assignments was investigated and compared in two different implementations of a course. In both groups, student performance on online assignments was compared to that of traditional written assignments. Performance trends were also compared between the beginning of the course and the end of the course. Students' relative performance on online assignments showed significant gain by the end of the course. Performance on both types of assignments and in the course overall was investigated as a possible function of computer self-efficacy, self-efficacy for self-regulated learning, and mathematics self-efficacy. (Received September 24, 2012)

1086-C1-2240 **Samer S Habre*** (shabre@lau.edu.lb), Lebanese American University, P.O.ox 13-5053, Beirut, Chouran 1102-2801, Lebanon. *Experimenting with MyMathLab*. Preliminary report.

Only a year and a half ago has MyMathLab been introduced to some mathematics classes at the Lebanese American University, particularly in freshman mathematics courses where the need for external help is mostly felt. Besides its educational benefits, one other consideration for adopting MyMathLab is the necessity to buy the course textbook in order to access the online course. This is in defiance to a persistent culture in Lebanon that promotes buying photocopied textbooks. Consequently, MyMathLab was used in Basic Mathematics Class, in Calculus 1, and in Calculus 2. Initially, students resisted the use of MyMathLab (and resisted buying the textbook); slowly however, more and more students bought the textbook and responded to the instructor's requests to submit assignments and quizzes. In addition, MyMathLab was initially optional but in the semesters that followed it became mandatory. Instructors were more comfortable using it and the culture of MyMathLab was spreading among students. The purpose of this talk is to report on the results of our experiment. In particular, I shall report on the students' performance and whether or not it has been influenced by the introduction of this interactive learning environment. (Received September 25, 2012)

1086-C1-2621 **James S Rolf***, 10 Hillhouse Avenue, Department of Mathematics, Yale University, New Haven, CT 06520. *The Impact of WebWork and Interleaving on Student Learning and Attitudes*. Preliminary report.

We report on the implementation of WebWork to deliver homework problems. In particular, we have attempted to measure student satisfaction with the WebWork experience, the impact on learning behaviors (e.g. persistence and collaboration), correlation with student performance, and student attitudes. Additionally, we have experimented with using WebWork to interleave homework problems from prior assignments with current material and report on the impact of interleaving on student performance and long term retention. (Received September 25, 2012)

1086-C1-2625 **Michael B. Scott***, mScott@csumb.edu. *Using Online Homework and Data Mining to Assess Student Learning in Mathematics Courses*.

Cal State Monterey Bay uses a web-based homework system to supplement Pre-Calculus, Calculus and other mathematics courses. The infrastructure of the homework system has expanded into a course management system used to coordinate every aspect of the course. Expansion of the system makes possible the collection of rich data streams about individual students. Mining these data enable longitudinal studies of student learning. The presenter will discuss correlations between students interactions with the system and overall course performance. Results of a pilot program incorporating online homework into a classroom setting will also be presented. (Received September 25, 2012)

Bridging the Gap: Designing an Introduction to Proofs Course

1086-C5-484 **Larry J. Gerstein*** (gerstein@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106-3080. *A Course for Bridging the Gap*.

An "introduction to proofs" or "transition" course has several fundamental and overlapping objectives: increasing the mathematical maturity of the students, introducing the students to an assortment of concepts that are likely to be useful in subsequent courses, and boosting the students' abilities to construct coherent proofs that can be read and understood by others. To design and teach such a course effectively, the instructor needs to start with some serious contemplation of what is meant by "mathematical maturity." In the talk I will offer some thoughts about this important notion (and its opposite), and then I will go on to describe a course and some specific

topics that I have found to be of particular value in enhancing that maturity and achieving the course's other objectives. (Received September 04, 2012)

- 1086-C5-1096 **Martin E Flashman*** (flashman@humboldt.edu), Department of Mathematics, Humboldt State University, Arcata, CA 95521. *Understanding the Problem: Unification, Generalization or Abstraction?* Preliminary report.

After having taught bridge courses with many different texts and organizations, the author has evolved an approach that recognizes that students can benefit in their first steps in trying to compose a proof by recognizing not only the structure of the problem statement but also whether the problem is one that calls for (i)unification of experience with simpler statements arising from a single context; (ii) generalization of experience to contexts that are similar but different; or (iii) abstraction beyond any more specific context. The author will provide examples and clarification of how this additional analysis has changed his pedagogy. This work is based on Daniel Solow's text "The Keys to Advanced Mathematics..." and G. Polya's classic, "How To Solve It.." (Received September 18, 2012)

- 1086-C5-1276 **Heakyung Lee*** (leeh@winthrop.edu), Winthrop University, Department of Mathematics, Rock Hill, SC 29732, and **Joseph P Rusinco** (rusincoj@winthrop.edu), Winthrop University, Department of Mathematics, Rock Hill, SC 29732. *Mathematical Reasoning course at Winthrop*. Preliminary report.

The mathematics department at Winthrop University in South Carolina offers an introductory proof course, Mathematical Reasoning. This course was created 2 years ago to develop students' proof writing and reasoning skills to help them prepare for their upper level mathematics courses. This course also serves to bridge the gap between computationally focused courses like calculus and more abstract courses like modern algebra. The course has several main components: weekly proof writing assignments from the textbook, a research article analysis, applied proof assignments by applying the proof techniques developed in class, and a portfolio assignment. The presentation will discuss each component listed above and provide information on what was a success, what was failed, and what needs to be improved in each component. A sample of common mistakes made by students on their proof assignments will be also shown. (Received September 21, 2012)

- 1086-C5-1408 **Jennifer B. Schaefer*** (schaeffe@dickinson.edu). *Becoming successful proof-writers through peer review, journals, and portfolios*.

With guidance from our Writing Program Director, we decided to move beyond standard homework and exams and develop new writing components for our department's writing-intensive introduction to proofs course. Peer review, journals, and portfolios were designed to place increased emphasis on revision, transfer, and writing to learn and to improve student performance on homework assignments and exams and in future math courses. We will discuss the details of each assignment and provide examples of student portfolios, the capstone piece which brought together all components of the course. (Received September 21, 2012)

- 1086-C5-1846 **Roberto C Pelayo*** (robertop@hawaii.edu), University of Hawaii at Hilo, Mathematics Department, Hilo, HI 96720. *Transition to Mathematical Proofs: Assessment of an online proofs course*. Preliminary report.

In most universities, transitional proofs courses are held in the second or third year of a math major's academic journey to prepare him/her for the rigors of mathematical writing in upper-level courses. At the California Institute of Technology, though, undergraduate students are expected to write fluent, complete proofs in the first quarter of their Freshman year. To address this unique situation, Caltech has established *Math 0 - Transition to Mathematical Proofs* as an online course for incoming Freshmen. This presentation will describe the framework of this course, as well as the various challenges associated to offering such a distinctive resource for its pre-Freshmen. Also, statistical and qualitative data demonstrating the effectiveness of this course will be presented. (Received September 24, 2012)

- 1086-C5-2134 **Sarah K. Bleiler*** (sarah.bleiler@mtsu.edu), **Denisse R. Thompson** (denisse@usf.edu) and **Mile Krajcevski** (mile@mail.usf.edu). *Lessons Learned from a Teaching Experiment Focused on Proof Validation*.

Mathematics education researchers have called for the design of explicit instructional sequences devoted to teaching the process of proof validation. Following this recommendation, we designed and implemented a structured set of activities for prospective secondary mathematics teachers (PSMTs) enrolled in a mathematics methods course with the intent of improving their proof validation skills. The instructional sequence was developed based on research literature that has shown undergraduates often (1) hold an empirical proof scheme, meaning they

employ or accept “proof by example” and (2) focus on (local) specifics of an argument rather than the (global) logical structure of an argument.

In this session we share a subset of the activities used to engage PSMTs in proof validation, present data collected from three implementations of the instructional sequence, and discuss the value of such activities and potential improvements/modifications to the instructional sequence. We hope participants will leave our session with a greater awareness and appreciation of major obstacles to undergraduates’ validation of mathematical arguments, and with potential strategies they can use at their institutions to help students improve in this area. (Received September 24, 2012)

1086-C5-2154 **Krystyna Kuperberg*** (kuperkm@auburn.edu), 221 Parker Hall, Mathematics, Auburn University, Auburn, AL 36849. *Teaching proving techniques using MIZAR proof checker.*

Proof checkers are computer programs that verify proofs written in a formal language that is very close to the language commonly used by mathematicians. The checkers provide a perfect tool for introducing students to the rigor of mathematical thinking. This talk will describe how one of the first proof checkers, MIZAR, was used in a classroom setting. Students wrote a detailed proof and checked its validity by formalizing the expressions in preparation for computerized verification. MIZAR-based theorem proving courses in logic, set theory, topology, algebra, and other areas of mathematics could be easily designed for various levels of undergraduate instruction. (Received September 24, 2012)

1086-C5-2648 **Jim Fulmer*** (jrfulmer@ualr.edu) and **Tom McMillan** (tcmcmillan@ualr.edu). *Teaching an Introduction to Proof Course Using Inquiry-Based Learning.*

This presentation describes an inquiry-based course pioneered at the University of Arkansas at Little Rock. Two mathematics department faculty members team-taught the course, Introduction to Proof, which was offered as a Selected Topics course, with a prerequisite of Calculus I. Our talk will cover warm-up activities (challenge problems to get the students comfortable working together), and the approaches we used in class to encourage students to write their proofs and to gain confidence in their abilities to communicate with others. The primary textbook for the course was the set of class notes, Introduction to Proof, by Ron Taylor of Berry College. The course was a trial run, which proved successful. As a result, Introduction to Proof, MATH 2350, will be required at the sophomore level for all mathematics majors beginning fall semester 2012. The authors express their appreciation to the Educational Advancement Foundation for financial support, and to Mike Starbird and his colleagues at the University of Texas at Austin for generously allowing us to attend well established and well designed inquiry based learning classes. (Received September 25, 2012)

1086-C5-2692 **Megan Paddack*** (m.paddack@snhu.edu). *Building a mathematical community while learning strategies for discovering and writing proofs.*

In September of 2009, I was one of two new mathematics faculty members in my department, which was historically a service department with no majors. Over the last few years we launched new majors in math and math education, which included offering an introduction to proofs course. While creating this course, I needed to balance the needs of our students with the expectations of a rigorous math major. I picked out a textbook, I deliberated on topic choices, and I created a syllabus with learning outcomes. Most importantly, I envisioned the students actively engaged, debating the validity and explanatory properties of their own proofs. If they could build a mathematical community and at the same time learn strategies for discovering and writing proofs, our students would be great mathematicians. Creating this classroom environment was as challenging as I thought it would be, and even more rewarding than I thought possible. I am amazed at how the first group of students responded to this course. They challenged each other, and challenged me. I have learned from that first experience and I am now teaching this course for the second time with a new textbook, and a better understanding of what topics might cause distress and how to promote even more engagement. (Received September 25, 2012)

1086-C5-2876 **Theresa L Friedman*** (tfriedma@coloradomesa.edu). *Bridge Course Assessments That Motivate and Engage.* Preliminary report.

In this presentation, I will discuss a student-discovery approach used to promote student understanding in our bridge course. The text that I used, Carol Schumacher’s Chapter Zero, is designed for just this purpose. In addition to some traditional testing, I developed assessments that would promote student interaction, discussion, and self-correction. Such assessments include journals, daily group and board work, weekly presentations with (graded) constructive feedback from classmates, and a final portfolio. These activities help to motivate student appreciation of statement analysis, careful articulation of arguments made, and appropriate proof method selection. To help mitigate some of the inevitable early frustrations, assessments contribute increasingly to

their grades as the semester progresses and as the students gain more proficiency with proof-writing techniques. (Received September 25, 2012)

Communicating Mathematics

1086-D1-315 **Audrey Malagon*** (amalagon@vwc.edu), 1584 Wesleyan Dr., Norfolk, VA 23502. *Calculus for Dummies: A Student Writing Project*. Preliminary report.

Inspired by the popular For Dummies series, I created writing projects for my Calculus I & II students asking them to summarize techniques, procedures, and central ideas in an easy to use reference manual. These projects are highly adaptable and have been well received by the students. I will describe the project design, share student examples and feedback, and discuss my goals for the projects which include better mathematical communication skills and content retention. (Received August 20, 2012)

1086-D1-489 **Matthew Wright*** (mwright@huntington.edu), 2303 College Avenue, Huntington, IN 46750. *Benefits of Collaborative Writing for Learning*.

Writing mathematics is an essential skill for students to develop in order to understand as well as communicate mathematics. Wiki-style collaborative writing is an effective tool in this process. In this talk, I will describe semester-long collaborative writing projects in both calculus and real analysis courses. Outcomes on student learning, student writing quality, and class interaction will also be presented from instructor and student perspectives. (Received September 04, 2012)

1086-D1-504 **Linda McGuire*** (lmcguire@muhlenberg.edu), Department of Mathematics & Computer Science, Muhlenberg College, Allentown, PA 18062. *(Explain It) x 3*. Preliminary report.

In this presentation we will describe an assignment specifically designed to develop student's oral and written communication skills. Called "Explain it x (times) 3," the assignment requires students to solve mathematical problems, and then present their solutions in three different ways: (1) written in a "proof-style" that a student of mathematics would understand, (2) written in a manner that any fellow college student would understand, and (3) written in a jargon-less, reporting style that could appear as an article for the general public in the local newspaper. In-class oral presentations of written work, complete with follow-up student-led Q&A sessions, are also required.

This assignment has been adapted for use in courses from introductory level liberal arts mathematics classes to junior/senior level courses for mathematics majors, and these varied assignments will be discussed. Specific examples of problems used, student work, assessment strategies, and student/alumni feedback will also be described in detail. (Received September 05, 2012)

1086-D1-552 **Julie C Beier*** (beier_jc@mercer.edu), Mercer University, Department of Mathematics, 1400 Coleman Avenue, Macon, GA 31207. *Scaffolding Writing in the Mathematics Classroom*.

Writing in mathematics is different than writing in other disciplines and often students are expected to learn this process through observation. As educators we can help students greatly improve written communication by scaffolding the writing process either in an assignment or across a semester. We will discuss the basic ideas of scaffolding, present several examples of ways to support writing through small and large tasks in classes for mathematics majors, and explore how to add effective structure to an existing writing assignment. (Received September 06, 2012)

1086-D1-605 **Su Liang***, 5500 University Parkway, San Bernardino, CA 92407. *Let Students Talk and Write Their Mathematics Ideas*.

Funded by the Teaching Resource Center of our university in 2011, I conducted a course development project that was designed to significantly change the traditional way (lecturing) of teaching Math 301A (the first course of Mathematics for Future Teachers). The goal of the project was to deeply engage students in communicating their mathematics ideas through multiple approaches. The class was structured in such a way so that the teacher minimized her lecture time to give the floor to the students, and students were the ones who talked or wrote their mathematics ideas most of the class time. This course development project has been implemented in three class section in winter 2012 and spring 2012. The students' feedback has been very positive. (Received September 08, 2012)

- 1086-D1-743 **Mark L. Daniels*** (mdaniels@math.utexas.edu), Department of Mathematics, 2515 Speedway Stop C1200, Austin, TX 78712. *Doing, Presenting, Speaking, and Writing Mathematics in an IBL Freshman Research Initiative (FRI) Mathematics Class.* Preliminary report.

Information about a course created to introduce STEM major freshman to the foundations of logical thinking and justification and designed to entice freshman into taking more mathematics courses will be given. Student attitudes and beliefs about the relevance of the course will also be explored.

The course named "From Numbers to Chaos" is taught using IBL methods where student presentation and communication of mathematics is essential. In addition, there is a large and sustained writing component to the course that teaches students how to conduct rudimentary research in mathematics and to write about this experience in a professional way. (Received September 11, 2012)

- 1086-D1-754 **Kimberly J Presser*** (kjpres@ship.edu), Shippensburg University, Department of Mathematics, Shippensburg, PA 17257. *Communicating Criticism: Helping students learn to critique mathematical writing and to improve their writing with criticism received.* Preliminary report.

Our department has a writing component in Introduction to Abstract Algebra, which is our first heavy proofs course, as part of our assessment plan. After my first novice attempts at constructing writing assignments for this class, I began incorporating peer reviews. In my experience, the students have a very difficult time providing quality criticism and useful feedback. I find this especially interesting given the number of students who plan on becoming secondary mathematics teachers, who will need to be providing feedback to students on a regular basis. This has led to an emphasis in class discussions on giving, receiving and using quality criticism. For this presentation, I will discuss the writing assignments and feedback process, the classroom discussion items and assignments which can enhance these efforts and outcomes from previous experiences. (Received September 12, 2012)

- 1086-D1-783 **Hannah R Robbins*** (robbins@roanoke.edu). *Using a Blog to Allow Proof Revisions.*

One of my major concerns about helping my students learn to construct well written proofs is that students submit each proof only once and never attempt to revise their writing. This is a major contrast with most other courses which teach good writing techniques to students!

In this talk, we will discuss how to use a course blog to allow students to revise their proofs as they learn to be good mathematical writers. I will share some experiences about assignment structure and student response to using a blog in my abstract algebra course. (Received September 12, 2012)

- 1086-D1-959 **Thomas Q Sibley*** (tsibley@csbsju.edu). *R⁴S: Reading, 'Riting, Rewriting, Rehearsing and Speaking.*

To meet university-wide goals our Mathematics Capstone requires seniors to develop skills not typically taught in mathematics courses. With help, our students learn to read appropriate journal articles and secondary sources on topics of interest to them. They write and rewrite an expository paper and give 20 minute presentations. I will share some ways I have found to help students towards these goals. (Received September 17, 2012)

- 1086-D1-969 **A S Elkhader*** (elkhadea@northern.edu), Department of Sciences and Mathematics, Northern State University, Aberdeen, SD 57401. *Examples on the use of communications in teaching college algebra as an honors course.*

This presentation will focus on how communicating mathematics, in written as well as oral forms, was used in classroom teaching of college algebra as an honors course at Northern State University. The presenter will share numerous practices that would enhance students understanding, appreciation of mathematics, and communication. Among such examples is solving algebraic problems without using any symbolic notations, using Internet search in the history and development of new mathematical notations, discussing the effect of modifying certain parameters in mathematical models that depict social issues, and finally examples on the casual use of mathematics in some newspaper articles as well as national and regional advertisements (Received September 17, 2012)

- 1086-D1-1045 **W. Ted Mahavier*** (ted.mahavier@lamar.edu), PO Box 100047, Lamar Univ., Beaumont, TX 77710. *Using Modern Tools to Enhance Communication in Moore Method Courses.*

R.L. Moore's Method was novel in the 1950s, and is still relevant today, especially as many mathematicians adapt IBL pedagogies to their courses. The method can be enhanced considerably with the use of modern technology. With students presenting every day at the board in my classes, accurate oral communication and confidence are developed side-by-side. To facilitate precise speaking and writing, we use multiple modern tools – digital

photography, Facebook groups, email and websites. We will discuss the specific details of how we implement these technologies to create a classroom that is enjoyable, covers significant material and develops both oral and written communication skills. (Received September 18, 2012)

- 1086-D1-1052 **Tara C Davis*** (tdavis@hpu.edu), 1164 Bishop Street, UB210A, Honolulu, HI 96813, and **Hung Lu**, 1164 Bishop Street, UB 520, Honolulu, HI 96813. *Student-centered versus instructor-centered approaches to teaching mathematics*. Preliminary report.

This action research study focuses on exploring whether the student-centered approaches such as group work and individual in-class problem solving and presentations are more effective than the traditional instructor-centered lecture approach in our math classes. We are interested in learning whether students have higher levels of confidence and lower levels of math anxiety when taught more actively. The study was conducted with about 70 students at Hawaii Pacific University during the Fall 2011 semester and continues in Fall 2012. Preliminary analysis shows that mean quiz scores are higher in the student-centered group and lower in the lecture group. The median quiz scores are lower in the lecture group. There are fewer zero quiz scores in the student-centered class across all the quizzes; the most at-risk students appear to attend class more and achieve fewer failing quiz marks than the lecture students. The grades in the student-centered class are higher at the lower quantiles. The percentage differences became less and less with increasing quantiles. Our presentation will include some focus on the use of student discussion and presentation during class time, based on responses to surveys as well as our observations of communication. (Received September 18, 2012)

- 1086-D1-1059 **Padraig M. McLoughlin** (mcloughl@kutztown.edu), 265 Lytle Hall, Dept. of Mathematics, Kutztown University of Pennsylvania, Kutztown, PA 19530, and **Perry Y. C. Lee*** (plee@kutztown.edu), 267 Lytle Hall, Dept. of Mathematics, Kutztown University of Pennsylvania, Kutztown, PA 19530. *Inquiry-Based Learning and the Moore Method Works: Giving Students the Opportunity to Effectively Communicate Mathematical Ideas*.

Learning requires doing, and only through inquiry is learning achieved. This paper proposes use of Inquiry-Based Learning (IBL) across mathematics curriculum. The authors opine that students understand by both asking and answering questions; by engaging; and, by explaining to one's self and one's peers' concepts. IBL creates a dynamic learning environment which enables students to understand math.

One author is new to IBL and is using IBL methods in his classes; he attended an IBL workshop sponsored by the MAA and the Educational Advancement Foundation (EAF) and is incorporating IBL-based style in his teaching methods. The other author has used a modified Moore method (MMM) in classes he has taught for about 30 years from freshman through graduate-level courses.

We discuss the techniques used to facilitate learning, and present both the successes and the failures. We focus on how IBL through speaking effectively forges students' confidence, and motivates students to hone their precise use of language to communicate math. IBL encourages students to delve deeply into concepts rather than shallowly be trained to regurgitate information.

(Received September 18, 2012)

- 1086-D1-1062 **Randall E Cone*** (conere10@vmi.edu), 439 Mallory Hall, Virginia Military Institute, Lexington, VA 24450. *Writing Mathematics: Creating an MCM-Based Capstone Course*.

The Mathematical Contest in Modeling (MCM) is a well-known and well-respected international undergraduate mathematics contest that takes place over the course of a long weekend in February of each year. This short presentation describes how one applied mathematics department, when faced with an ever-increasing number of graduating mathematics majors, rewrote its capstone course to be a writing-intensive experience, preparing senior-level students to compete in the MCM. Three major questions are addressed within the presentation: what are the design and implementation challenges while creating and piloting such a course? What are some of the issues encountered while working to get such a course designated as an official writing course at the institution level? How has the new course evolved, in terms of both form and content, over its first two years? (Received September 18, 2012)

- 1086-D1-1212 **David M. Clark*** (clarkd@newpaltz.edu), Mathematics Department, State University of New York, New Paltz, NY 12561. *Reasoning and Communication through Axiomatic Geometry*.

The author will describe the use of his new text, *Euclidean Geometry: A Guided Inquiry Approach* (American Mathematical Society MSRI-MCL series #9) as a means of teaching reasoning and oral communication. This book gives a new and mathematically sound system of axioms for Euclidean geometry that incorporates modern advances in mathematics which were not available to Euclid. Students solve problems and prove theorems on

their own in an inquiry-based format, and then present and defend their results in a friendly and supportive classroom environment. Lecturing is minimized, as the primary role of the instructor is that of a mentor and a guide. Through this process students learn to think critically and creatively, to say what they mean and to mean what they say. Communication skills are challenged and developed through the need to explain their own complex ideas to their peers and convince them that they are correct. (Received September 20, 2012)

1086-D1-1257 **Jeffery T. McLean*** (jtmclean@stthomas.edu), Mail # OSS 201, University of St. Thomas, 2115 Summit Avenue, St. Paul, MN 55105. *Capstone Communication Strategies.*

A presentation of the strategies used in the fall semester offering of the course Advanced Mathematics: Exploration and Exposition. This is the capstone course for the students intending to teach high school mathematics. The speaking and writing skills have been used earlier in this and another course and include daily presentations, discussion and written homework assignments and a major project with a written and oral component. The nature and philosophy of these assignments as well as grading rubrics will be presented. Evaluation of this approach will include student input. (Received September 20, 2012)

1086-D1-1290 **Violeta Vasilevska*** (violeta.vasilevska@uvu.edu). *Scaffolding Oral Communication in Math Classes.*

One way the presenter has encouraged oral communication in math classes is by preparing written class notes that contain information necessary to attack problems or write proofs. Students are then guided through carefully structured questions and discussions to encourage active participation in the construction of knowledge through inquiry and investigation in class. This teaching method promotes more student participation in class, makes the class more active and encourages lively discussions among students. Time permitted, some written projects given in upper level classes will also be discussed. (Received September 20, 2012)

1086-D1-1523 **Yu-Ju Kuo***, yjkuo@iup.edu. *How does giving oral presentations and typing up all assignments help students?*

Producing typed reports and giving oral presentations for the final project have been major components of assignments in my dual and master-level graduate courses for years. Through time, the instructions for the report have become more detailed and the rubric for evaluating oral presentations is also shared with students a week prior to their scheduled presentation time. After running a writing intensive class two years ago, I now require students type all of their homework assignments and give students opportunities to turn in a draft a few days before the deadline for my quick feedback. In this presentation, I will share a series of assignments to help students develop their final projects, the mechanism for evaluating students' oral presentations, and how the typed assignments help students and the instructor. (Received September 23, 2012)

1086-D1-1611 **Nina Juliana White*** (whitenj@umich.edu). *Giving Students an Active Role in Creating Homework Feedback.* Preliminary report.

One of the learning goals of the mathematics content course for pre-service elementary teachers at University of Michigan is improved mathematical communication. In past semesters, I have given students opportunities to submit revisions of their graded work, hoping this would lead to improvement. However, I was rarely satisfied with the results because (1) their second drafts seldom incorporated original revisions, (2) they seemed to make changes I suggested pro forma instead of with thoughtful consideration, and (3) they did not generalize the feedback and apply it to future problem sets.

In response I've implemented a mechanism for giving my students a more active role in evaluating their justification-intensive problems. I no longer grade their first drafts of justification-intensive problems. Instead, students revise their own first drafts in class in light of class discussion. Later, they evaluate sample solutions of problems online. Finally, they submit revisions in a portfolio, including a description of their revision process.

In this talk I'll present examples of student work from this semester and discuss the kinds of revisions students make to their solutions using this system. (Received September 23, 2012)

1086-D1-1614 **Vicky L Klima*** (klimavw@appstate.edu). *Improving communication skills through student-produced videos.* Preliminary report.

Mathematics instructors agree that a student's journey towards a problem's solution is more important to the student's learning than the particular solution he or she finds. In this talk we discuss a method for students to communicate this journey through video. We will introduce a few free, high-quality video-capture software packages. Students can easily use these packages to record their solutions to multi-step problems, particularly problems that require the use of technology such as spreadsheets or computer algebra systems. The presenter

will discuss how her students' ability to verbally communicate mathematics improved throughout a semester in which video assignments were made and reviewed regularly. (Received September 23, 2012)

- 1086-D1-1617 **Catherine Beneteau** and **Zdenka Guadarrama***, guadarrama@rockhurst.edu, and **Jill Guerra** and **Laurie Lenz**. *Communication as a process skill in the POGIL classroom: Implementation techniques*. Preliminary report.

Process Oriented Guided Inquiry Learning (POGIL) is an instructional strategy that guides students toward the discovery of a particular concept by working in self-managed teams of three or four on specially designed POGIL activities. A POGIL classroom focuses both on the achievement of content knowledge and the development of process skills such as effective communication of mathematical arguments, information processing, critical thinking, teamwork, and metacognition. In this talk we will provide examples of POGIL group management roles, classroom reporting techniques, and activity implementation strategies that result in students learning how to effectively communicate mathematics in written and oral form. (Received September 23, 2012)

- 1086-D1-1901 **Hayden Schaeffer***, UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095. *Writing and Mathematics*.

In the style of a "writing across the curriculum" pedagogy, this course combines a rigorous mathematics curriculum with a small discussion-based seminar. The material is a mixture of mathematics, group activities through physical experiments, and writing assignments. The focus is on both learning and communicating mathematics through discussions, presentations, and expository papers. The action of writing a paper is analogous in many ways to a proof: one needs to set up a formal argument in support of a main claim. The process itself - specifically conceptualizing, constructing, and revising - are skills that re-enforce a standard mathematics curriculum. For mathematics and science majors, the course teaches them rigorous mathematics while improving their interpersonal, communication, and writing skills. This provides a broader education for the students while also making them more marketable to both academia and industry. For students in non-technical majors, the course provides an opportunity to introduce students to mathematics who may not normally choose to do so due to their particular fears, anxieties, or lack of interest. (Received September 24, 2012)

- 1086-D1-1947 **Suzanne Sumner*** (ssumner@umw.edu), 1301 College Avenue, Fredericksburg, VA 22401. *Intensive Experiences for Undergraduate Mathematics*.

Students often leave mathematics courses performing the necessary calculations, yet with no deep understanding of the material. If assignments stress the communication of quantitative ideas, students must articulate the mathematics, and it becomes clear whether they have a thorough understanding. Three intensive courses will be demonstrated: Learning by Exploring in Mathematics of Chaos first-year seminar; Learning by Writing in History of Mathematics; and Learning through Speaking in Introduction to Mathematical Modeling, studying environmental problems. (Received September 24, 2012)

- 1086-D1-2111 **Kimberly A Roth*** (roth@juniata.edu). *Communicating in a Statistical Consulting Course*.

The statistical consulting course at Juniata College is a course where the students complete projects on data from client departments across the campus. Developing the scaffolding to allow the students to develop the necessary skills of speaking and writing for the course is an on going process. I will discuss the successes and areas for improvement in the initial assignments for skill acquisition along with the final project from the class. Also I will discuss the continued progress of the students as they use their skills after the class both in subsequent classes and in the workplace. (Received September 24, 2012)

- 1086-D1-2164 **Krystyna Kuperberg*** (kuperkm@auburn.edu), 221 Parker Hall, Mathematics, Auburn University, Auburn, AL 36849. *Presentations by participants in class consisting of two distinct groups of students*.

Classroom presentations by students may pose an unexpected problem if the level of preparation of the audience is not even. This regularly happens in code-share courses mixing undergraduate and graduate participants or in courses attended by both math and non-math majors. Advanced students stress the ideas and mathematical correctness, understandably very important components of the presentation, but the level may be intimidating to the less experienced students. A successful experiment satisfying both groups of students will be described. (Received September 24, 2012)

- 1086-D1-2330 **Susan H. Marshall*** (smarshall@monmouth.edu). *Using a modified-Moore method to teach communication in mathematics.* Preliminary report.

The junior-level number theory course at Monmouth University focuses heavily on communicating mathematics, both orally and in writing. It is a *writing-intensive course* as well as a course in *reasoned-oral discourse* (two requirements of our general education curriculum). In order to address the learning outcomes of these course types, as well as the mathematical goals of the course, we have been teaching it using a modified-Moore method. This talk will discuss both the successes and challenges of this approach. (Received September 25, 2012)

- 1086-D1-2370 **Michael Starbird***, starbird@mail.utexas.edu. *Speaking and Thinking.* Preliminary report.

When students speak about mathematics extemporaneously, they are perforce directly revealing the depth and clarity of their understanding. Creating a safe environment in the classroom allows students to show the authentic status of their knowledge and of their intuition about the mathematical theme being considered. At that moment there is complete attention on the opportunity for guidance. No moment of attention is more focused than the moment when a student is formulating ideas as part of the speaking and thinking process. Speaking regularly in class with the aim of conveying specific ideas to other students who may not know them is a great way for the student to learn through teaching. (Received September 25, 2012)

- 1086-D1-2451 **Ann C. Stewart*** (stewart@hood.edu), 401 Rosemont Ave., Frederick, MD 21701, and **Jill Bigley Dunham** (dunham@hood.edu), 401 Rosemont Ave., Frederick, MD 21701. *From "A Letter Home" to Senior Capstone: Writing Across the Major at Hood College.*

"Demonstration of the ability to write and speak standard English (included in the grade evaluation for every course at Hood College.)" This phrase appears under the General Requirements section of the catalog for Hood College. Your college catalog may state something similar. How can this be implemented in the mathematics curriculum? We outline our method of integrating writing and speaking about mathematics into every course in the major, starting with Calculus 1. We will share our structure for supporting the students' developing writing and speaking skills, along with our evidence for success. (Received September 25, 2012)

- 1086-D1-2495 **Lesley W. Wiglesworth*** (lesley.wiglesworth@centre.edu). *Videotaping as a Means to Improve Students' Oral Communication Skills.*

Students often move through mathematics classes listening to the professor deliver the proofs of important theorems. They are rarely faced with the task of reading a fundamental theorem, comprehending the theorem's proof, and communicating it to others. In higher-level courses, students should be charged to communicate mathematics with grace. In this talk, a three step assignment that requires students to videotape their proof presentation and meet with the professor prior to presenting to the class is discussed. In addition, evidence of improvement in students' oral communication skills will be presented. (Received September 25, 2012)

- 1086-D1-2496 **Rebecca L. Jayne*** (rjayne2@washcoll.edu), Washington College, 300 Washington Ave., Chestertown, MD 21620. *Improving Proof Writing Through Peer Review.* Preliminary report.

In my real analysis course, one of my goals is for students to hone their proof writing skills. One of the techniques I use to achieve this goal is peer review. In this talk, I will discuss some of the activities that I have done in class and assignments given for outside of class, including typing proofs and having students critique them in groups, partner proofs, and reviewing proofs in pairs before turning them in for a grade. I will also comment on the effectiveness of these activities. (Received September 25, 2012)

- 1086-D1-2498 **Michelle L Ghrist*** (michelle.ghrist@usafa.edu) and **James S Rolf**. *The Great Spline Mystery.*

Cubic splines are a commonly used way to create an interpolating function, a function which goes through a set of discrete data points; cubic splines are essentially piecewise cubic polynomials. There are several different types of commonly used cubic splines which differ only based on which choice of boundary conditions is imposed.

Over the past eight years, we have developed a Java applet which creates various approximations (including cubic splines) to a user-defined function. In addition, we created an associated writing assignment that allows students to practice good mathematical communication; we have used this assignment in various numerical analysis classes. In this talk, I discuss one particular aspect of this writing assignment: an exercise in which students are asked to logically deduce which kind of spline is being used by ApproxTool. This exercise has proved to be extremely difficult for students and stretches their understanding of the various splines as well as their problem-solving and communication skills. I examine various strategies for solving the great spline mystery and discuss the impact of this assignment on students' written communication skills.

The ApproxTool applet is available free at <http://www.jimrolf.com/java/approxTool/approxTool.html>. (Received September 25, 2012)

- 1086-D1-2510 **Rebekah B. Johnson Yates*** (rebekah.yates@houghton.edu), Mathematics and Computer Science Department, Houghton College, 1 Willard Ave, Houghton, NY 14744. *Writing in Calculus I: Is It Derivative or Integral?*

"Mathematics, rightly viewed, possesses not only truth, but supreme beauty..." (Bertrand Russell in *Mysticism and Logic*). Too often, students in Calculus I become so mired in the details of derivative rules and other procedures that they miss the overarching beauty of the subject. To help my students see the big picture of calculus and to learn to communicate about that picture more broadly, I have created several writing assignments. In this talk, I will present highlights from the assignments and my students' responses to them. (Received September 25, 2012)

- 1086-D1-2546 **Sarah E. Wright*** (swright@holycross.edu), Worcester, MA 01610. *Using a Modified Moore Method to Improve Communication*. Preliminary report.

This talk will explore the benefits of IBL methods on students' communication skills in a calculus class. The focus will be on oral communication, but we include ideas to maintain clear goals and standards for good mathematical writing. It is predictable that a student centered course that forces students to express their ideas orally to the class would improve these skills. A more surprising outcome seems to be the students' ability to ask clear, concise questions, and patiently answer questions from their peers. (Received September 25, 2012)

- 1086-D1-2549 **Jeremy Case*** (jrcase@taylor.edu), 236 W Reade Ave, Upland, IN 46989. *Interactions with the Writing Center*. Preliminary report.

Many institutions have writing centers which are intended to help students with compositions, research papers, and general academic writing. One common service of a writing center is the availability of peer writing consultants. Can consultants help juniors in a mathematics seminar course write their major mathematical paper even if the consultants are not mathematics majors? Alternatively, one successful approach in developing mathematical skills is the use of perfect proofs. Used in an Introduction to Proofs course or Abstract Algebra, perfect proofs require students to resubmit a proof until the proof is correct in both argument and style. Do mathematical students then connect their mathematical development to other areas of writing? This presentation will report on a study with the writing center examining the effectiveness of various writing strategies from the perspective of the students. We will examine the changes in student perceptions and attitudes of their abilities in mathematical writing and whether or not they are able to transfer their mathematical skills and thinking to other areas. (Received September 25, 2012)

- 1086-D1-2677 **McKenzie Russell Lamb*** (1ambm@ripon.edu), 300 Seward Street, PO Box 248, Ripon, WI 54971. *Using Turing Machines to Level the Playing Field in a Math for Liberal Arts Course*. Preliminary report.

One of the primary challenges of teaching math for liberal arts courses lies in dealing with the wide range of ability levels and backgrounds of the students in these classes. Finding topics that are simultaneously accessible to the weakest students in the class and challenging to the strongest is difficult. I will describe my attempts to use ideas from the theory of computation (finite automata, Turing machines, etc) to accomplish this. In particular, I will discuss using finite automata to motivate mathematical induction, using regular languages to motivate proof by contradiction, and using the notion of language recognition to motivate cardinality. I will also describe some activities that lead students to discover and develop these ideas on their own. The title of the course I am teaching using this scheme is "Mathematical Thinking and Writing." Therefore, the activities will emphasize using this circle of ideas to practice both formal and informal exposition of mathematical concepts. (Received September 25, 2012)

- 1086-D1-2708 **Joe Latulippe*** (jlatulip@norwich.edu), Mathematics Department, 158 Harmon Dr., Northfield, VT 05663, and **Christine Latulippe** (clatulip@norwich.edu), Mathematics Department, 158 Harmon Dr., Northfield, VT 05663. *Writing Projects in Mathematics: Student Data and Suggestions Gained from Our Experience*.

Although writing in mathematics has many benefits for students, creating and grading worthwhile writing projects can be more time consuming than utilizing more traditional forms of assessment, which often prevents faculty members from assigning them. To encourage using writing projects, we will share lessons learned through our experience as well as student data regarding writing projects in mathematics. Audience members will see an example of a single writing project prompt which has been successfully utilized in a calculus, differential equations and mathematical modeling course. Survey data that we have collected from differential equations

students illustrates that they perceive commonly cited benefits about writing in math (like exploring practical uses of mathematics, deepening content knowledge, and strengthening communication). We also share other student cited benefits to writing that instructors may not have considered before. (Received September 25, 2012)

1086-D1-2765 **Geoffrey W Buhl*** (geoffrey.buhl@csuci.edu), 1 University Drive, Camarillo, CA 93012. *A Writing Guide and Rubric for Mathematics.*

As part of campus wide curricular efforts, the mathematics program at CSU Channel Islands has developed a writing guide for mathematics and a rubric for evaluating the communication of mathematical work. Both are motivated by the idea that good mathematical exposition must be correct, complete, clear, and creative.

The mathematics writing guide is designed to help students submit written homework that is well-written and effectively communicates their understanding of mathematical concepts and techniques. An added benefit is that such written work is much easier to correct. Instructors expose students to the writing guide at the beginning of course and use samples of student work shape students' understanding instructors' expectations for written work.

A mathematics rubric developed as part of a General Education reform uses the concepts correctness, completeness, clarity, and creativity to assess students ability to solve and communicate solutions to mathematical problems. An outcome of this work is the use of proof portfolio assignments, that are used in multiple course in the mathematics curriculum. Student select and revise their best proofs from a course and package them into a portfolio that is then assessed using the mathematics rubric. (Received September 25, 2012)

1086-D1-2847 **Yelena Baishanski***, ybaishanski@lagcc.cuny.edu, and **Reem Jaafar**. *How can we help students "do" mathematics? Writing activities to challenge thought and elicit mathematical understanding.* Preliminary report.

For students with little experience in mathematical thinking and conceptualization, writing-to-learn activities can be particularly effective in promoting discovery and understanding. For community college students embarking on a first Calculus course in particular, writing activities can help facilitate the transition from an "apply the formula" approach to problem-solving to a "discover the formula" initiation to mathematical knowledge-building. Having identified several common challenges faced by community college students in a beginning Calculus course—including difficulties using mathematical notation, applying theorems, and understanding the language of proofs—we present several writing-to-learn assignments, ranging from in-class activities to more formal, revised assignments, that address these difficulties. Showcasing student work and feedback to highlight the learning objectives different writing tasks help attain, we argue that writing-to-learn activities not only help students cement mathematical knowledge, deepen understanding and develop appreciation for the rigor and concision of mathematical language, but also enable students to develop questioning and learning habits essential to their success in any field. (Received September 25, 2012)

1086-D1-2855 **Joyati Debnath*** (jdebnath@winona.edu), Winona, MN 55987. *Enhancing Communication in Mathematics.*

We all want our students to be able to think mathematics, talk mathematics and write mathematics. We want them to experience lively engaged mathematics instruction where they participate in their own learning. In this presentation various class activities and assignments will be discussed that successfully helped students to improve on their communication skills in mathematics classes. (Received September 25, 2012)

1086-D1-2908 **Patricia Hale*** (phale@csupomona.edu), Cal Poly Pomona, Department of Mathematics and Statistics, Pomona, CA 91768. *Using Large Surfaces to Enhance Students' Communication Skills.*

Having students do group-work on large surfaces (blackboard or large paper taped to the walls) provides students the opportunity to communicate with each other both verbally and in writing. Examples will be presented of utilizing this type of group-work in a wide range of courses. In this classroom setting, spontaneous student presentations to the class frequently occur and students' general communication skills improve. Further, students' writing skills significantly improve as they are required to submit solutions, with complete explanations, to the problems that they worked on in class. (Received September 26, 2012)

Computational Modeling in the Undergraduate Curriculum

1086-D5-151 **Paul R Bouthellier*** (pbouthe@pitt.edu), 504 East Main Street, Titusville, PA 16354.
Approximating the Mass, Volume, Cross-Sectional Areas, Surface Areas and Trajectories of Projectiles.

In this talk we shall use computational methods to approximate flight trajectories, maximum height and distance and the angle necessary to reach a maximum distance for the following problems: striking a golf ball with a club and launching an object out of a cannon. Using Studio 3D Max we create triangular mesh models of our objects from which we can estimate the object's mass, volume, cross-sectional and surface area. This is done by writing a program in 3D Max to loop through the faces making up the mesh and computing the areas and volumes using the edges as vectors (to find surface and cross-sectional areas) and the vertices to create tetrahedrons (to find volumes and masses). With the above approximations of the object's mass and cross-sectional area (also incorporating the object's coefficient of drag and rotation, gravity, and the effects of wind), the vector differential equations for velocity and acceleration are then numerically solved to approximate the trajectory of the object in R3. This trajectory is then programmed and rendered in the 3D graphics package Poser. The objects trajectory can then be studied from any point and angle in R3 and the model can be freely rotated to study the results. (Received July 30, 2012)

1086-D5-357 **Pablo Ulises Suarez*** (psuarez@desu.edu), 1200 N Dupont Hwy, Dover, DE 19901.
Introducing the Split Step Fourier Method with MATLAB. Preliminary report.

The Step Split Fourier Method(SSFM) provides an excellent methodology for learning and teaching how to solve time dependent partial differential equations. This method is ubiquitously used in engineering and physics applications. In this talk, we present the simplicity of this method by solving the Linear and Nonlinear Schrödinger Equation and with the aid of MATLAB, a numerical software package commonly used in undergraduate courses, we demonstrate a straight forward implementation. Extension to other type of problems can be done by using the basic SSFM algorithm and the code presented here can easily be modified to accommodate these any new situations. (Received August 24, 2012)

1086-D5-578 **William P. Fox*** (wpfox@nps.edu), 2977 Sloat Road, Pebble Beach, CA 93953.
Empowering Decision Makers Through Technology. Preliminary report.

We teach a three course sequence in mathematical modeling that includes deterministic models, stochastic models, and decision theory models. Our students are weak mathematically but they are able to solve and interpret very sophisticated problems because of the power of the computer. We are limited to Excel since our students all have access to Excel both during class and will have access to Excel at work after graduation. Within the time constraints, I will present several brief scenarios, one from each course, and quickly describe the modeling and the use of the computer to solve problems, aide in sensitivity, and help interpret the results. (Received September 07, 2012)

1086-D5-785 **Phil Gustafson***, Colorado Mesa University, Mathematics Department, Grand Junction, CO 81501-3122. *Student Projects using Microphones and the FFT.* Preliminary report.

The ubiquity of digital signals in our technological society helps to drive advances in computational modeling and the use of computational software such as MATLAB. For undergraduate students, modeling and analyzing student generated sound waves is a great way to gain a better appreciation for applications of calculus and the use of MATLAB. In this presentation we share classroom projects that utilize microphones, Audacity and MATLAB for the purpose of capturing and displaying student voice waves and analyzing their frequency content; and for exploring signal processing applications such as JPEG and MP3 compression. (Received September 12, 2012)

1086-D5-870 **Joy L. Becker*** (joy.becker@wartburg.edu), Mathematics, Comp. Sci., and Physics Dept., 100 Wartburg Blvd, PO Box 1003, Waverly, IA 50677, and **Brian J. Birgen** (brian.birgen@wartburg.edu), Mathematics, Comp. Sci., and Physics Dept., 100 Wartburg Blvd, PO Box 1003, Waverly, IA 50677. *A Modeling Approach for First Semester Calculus.*

Calculus at Wartburg is taught from the perspective of modeling with differential equations. Students construct models and solve differential equations using VenSim PLE, a numerical solver which is free for educational use. These models, including bungee jumpers, hot air balloons, and rockets, are beyond the scope of a typical first semester calculus course, but are easily achieved using VenSim. The final project in the course requires students to make connections between calculus and various partner disciplines, underscoring the relevance of mathematics to their future careers. (Received September 14, 2012)

- 1086-D5-1128 **Gabriella Marie Muscat*** (muscat.gabriella@gmail.com), 211 Post Hall, Adelphi University, 1 South Ave., Garden City, NY 11530, and **Salvatore P Giunta** (sg Giunta@adelphi.edu), 211 Post Hall, Adelphi University, 1 South Ave., Garden City, NY 11530. *Analyzing the Bald Eagle Population: Difficulties and Successes*. Preliminary report.

One application frequently covered in Mathematical Modelling courses is an analysis of statistical data. We will discuss a common project topic: given a set of population data (including age distribution, migration patterns, and life expectancy), fit curves to the data and project future populations. In particular, we discuss the practical difficulties students may encounter in trying to gather real-world data of this form, specifically with (formerly) endangered species such as the Bald Eagle; low population numbers may call into question the statistical significance of the available data. We also present a case study incorporating the Bald Eagle and Golden Eagle Protection Act into our data to explain why these populations suddenly stopped decreasing. (Received September 19, 2012)

- 1086-D5-1229 **D Scott Dillery*** (dillerys@lindsey.edu), Lindsey Wilson College Mathematics, 210 Lindsey Wilson Street, Columbia, KY 42718. *Design and Build of an Open Canoe: A Natural Path to Computation*.

Designing and building an open canoe has ample opportunity to work with today's computing power as it relates to Calculus. Classical techniques such as divided differences and numerical integration are utilized to approximate derivatives in data and compute non-trivial surface area and volume for designs. Newer technologies are also utilized to perform interactive techniques and to take advantage of interfaces that are now ubiquitous in the professional world. These newer technologies include spreadsheets, computer algebra systems (CAS) and sketch pads. A major computational problem is to create cross sections of an inner surface that is concentric to a compound surface that makes the outer hull. Both errors due to mathematical approximation in interpolation and due to physical limitations of the materials used in construction need to be understood. Further, the understanding of numerical approximation is put to use in checking the adherence of the physical product to the original design. Calculus topics for which some form of technological computation naturally arises include derivatives, integrals, optimization, parameterized curves, and Taylor series. This talk presents how the canoe design project was implemented in a second semester Calculus course. (Received September 20, 2012)

- 1086-D5-1561 **Khairul Islam*** (mislam4@emich.edu), Department of Mathematics, Eastern Michigan University, Ypsilanti, MI 48197. *Modeling and Evaluation Strategy in Undergraduate Calculus Curriculum*.

Fitting models to empirical data are important phenomena in real-life situations. Often, modeling in calculus class is done superficially without appropriate strategies and an adequate evaluation of models. Because introductory calculus covers the mathematical skills (for example, optimization criteria) necessary for fitting models, it is imperative that the students receive a thorough insight and evaluation of models as a part of the curriculum. This talk provides modeling and evaluation strategies to fitted models using empirical data which is important to enhance learning process. (Received September 23, 2012)

- 1086-D5-2053 **Daniel G Kim***, 618 Sutton PL, Ashland, OR 97520, and **Sungsook Kim** (sskim@pcu.ac.kr), Mathematics Department, 155-40 Baejae-ro, Seo-Gu, Daejeon, 302-735, South Korea. *Some Class Activities of Digital Processing Using Mathematica and MathCAD*. Preliminary report.

The area of digital image processing has great amount of resourceful opportunities in teaching mathematics because this modern field synthesizes a wide range of mathematical disciplines. We found that mathematics students engage into this topic quickly with curiosities. In this talk we introduce some examples of digital image and sound processing that were successfully used in linear algebra and undergraduate seminar style courses. Mathematica and MathCAD will be used to demonstrate how digital images and sounds are obtained, stored, processed, and also created through mathematical methods. If time is allowed, student feedbacks of these activities may be shared. (Received September 24, 2012)

- 1086-D5-2409 **Erica Slate Young*** (erica.slate@uah.edu) and **Jack Bookman** (bookman@math.duke.edu). *Use of 3D Modeling Software in Undergraduate Math and Science Courses: Lessons Learned From Implementation Research*.

The software featured in this talk is DIYModeling, developed as part of a multi-institution, NSF-funded Phase 2 TUES project. This software enables students to build 3D simulations by concentrating entirely on the underlying science and mathematics instead of spending time programming or using software to create/display 3D images. Students building such simulations can learn a great deal about science and mathematics by building the models

underlying simulations, by using the simulations to explore the implications of their models, and, when possible, by validating their models against experiments, observations, and data. The purpose of this paper is to discuss the results of implementing DIY modules at some of the participating institutions (USMA, USAFA, Emporia State & Georgia Gwinnett College). We will describe the different ways we have observed DIY used, both in and out of the classroom, such as teacher demonstration, student use of pre-built simulations to explore parameters or to check their work, and student construction of simulations using their own mathematical models. We will highlight both the successes as well as the lessons learned and also examine possible future research questions stemming from this project. (Received September 25, 2012)

Developmental Mathematics Education

1086-E1-155 **Joan E Brown*** (joan.brown@enmu.edu), 1500 S. Ave K, Station 18, Portales, NM 88130, and **Tom R Brown**. *Developmental Math Redesign - What's Been Working*. Preliminary report.

Low pass rates and low retention are big issues in developmental math. Many post-secondary institutions not only are redesigning the way developmental math is taught, but also redesigning what math is taught. We will describe and show you what we have been doing to redesign our developmental math sequences and what innovations have shown success or the promise of success. We will show you our success rates for one course and our success rates for our developmental sequences before and after changes. Our redesign strategies include the Emporium Model, design of a one course prerequisite for college level math, and technology in the classroom. We will also describe and show you how we have joined the technology era and how that change has dramatically improved our students' success beyond anything we have tried in the past. Technology enhancements we will present include tablet PCs, lecture guides, wireless projectors, document cameras, laptop carts, computer labs, lesson videos, and homework software. (Received July 30, 2012)

1086-E1-397 **Ward E. Canfield*** (wcanfield@nl.edu), 1827 E Bittersweet Ln, Mount Prospect, IL 60056. *Course Redesign: Rethinking Instruction and Assessment in Developmental Mathematics by Taking Advantage of Computer Technology*.

The current status of developmental mathematics can be discouraging; much data shows that it is not enabling students to achieve their goals. It often delays or prevents their attainment of a college degree. Reform efforts seek to meet the varied needs of student populations, including those who have low skill levels, higher skill levels, and learners with a variety of abilities, while infusing "pizazz" of various sorts into courses in order to motivate students. However, many of these efforts are simply experiments with theories of change, the results of which are not known for a long time, and which have no clear vision of how to create significant and sustainable change. Successful reformed courses, on the other hand, seem to share five basic characteristics. They: 1) redesign the whole course, 2) encourage active learning, 3) provide individualized assistance for all students, 4) build upon ongoing assessment and prompt feedback (often automated), and 5) ensure sufficient time on task and monitoring of student progress. They aim at accelerating students' progression through developmental education while improving learning outcomes and reducing their financial aid challenges. This talk illustrates one such reformed approach which takes advantage of computer technology. (Received August 29, 2012)

1086-E1-460 **Maggie Lee McHugh*** (mmchugh@uwlax.edu), 1007 Cowley Hall, 1725 State Street, La Crosse, WI 54601, and **Jennifer J. Kosiak** (jkosiak@uwlax.edu), 1004 Cowley Hall, 1725 State Street, La Crosse, WI 54601. *FastTrack: A Developmental Mathematics Summer Hybrid Program*. Preliminary report.

To address the increasing number of developmental mathematics students at the University of Wisconsin- La Crosse, a hybrid mathematics program—FastTrack—was implemented during Summer 2012. Thirty-eight students who placed into Developmental Mathematics were invited to participate in the program, namely STEM majors and multicultural students. During the summer, students spent six weeks online working through digital learning objects and taking quizzes on each module. Students moved to campus one week prior to the start of the academic school year. Students then participated in math workshops and learned about student services available to assist them academically and socially. After retaking the placement exam, 37 of the 38 students moved out of developmental mathematics; 25 students placed into College Algebra with another 12 students moving into Pre-Calculus or Business Calculus. During the Fall 2012 semester, FastTrack students participated in supplemental instruction aimed to continue the mathematics success found in the summer. This presentation will further explain the details of the online and face-to-face program, assessment measures, and subsequent programming aimed to assist students throughout their college career. (Received September 03, 2012)

- 1086-E1-479 **Jerry C Obiekwe*** (accessx@uakron.edu), P. O. Box 411, Orrville, OH 44667. *Learning and Study Strategies Still Remain Relevant Factors in Predicting Academic Success in Developmental Mathematics.*

It is common knowledge that open-admission institutions particularly, community colleges, offer developmental mathematics courses and a good number of their students are placed in one of the remedial mathematics courses. The idea is to prepare them for college level math courses, but unfortunately not all of them succeed, which in turn often lead to their dropping out of the institution. There may be some correlation between success in college-level remedial mathematics and educational persistence. Minorities and low-income students are usually most affected. Consequently, helping these students succeed in developmental mathematics is a critical issue that must continually be addressed as it has enrollment management, economic and social mobility implications. This study examined the predictive characteristics of learning and study strategies with regard to developmental mathematics. The results and its implications to teaching and learning will be the focus of this presentation. (Received September 04, 2012)

- 1086-E1-548 **Mary Kay Abbey*** (marykay.abbey@montgomerycollege.edu), 7600 Takoma Avenue, Takoma Park, MD 20912. *Redesign for Non-Stop Learning.*

Montgomery College redesigned pre-algebra and elementary algebra, creating a self-paced mastery-based course which can be finished in one semester or two consecutive semesters, with the opportunity to also complete intermediate algebra. The planning process which studying other models around the country and culminated with site visits will be discussed. Buy in from our administration was key. The implementation process as well as success and retention data will be shared. (Received September 06, 2012)

- 1086-E1-727 **Victor I Piercey*** (victorpiercey@ferris.edu), Ferris State University, Department of Mathematics, 820 Campus Drive, ASC 2021, Big Rapids, MI 49307. *Inquiry-Based Learning in a Developmental Mathematics Course.* Preliminary report.

Conducting inquiry-based lessons in a developmental mathematics course presents several challenges, such as addressing student motivation and including all of the traditional topics necessary for the next course. In this talk, I will describe some of my successes, failures, and reflections from my experience using inquiry-based learning in a developmental algebra course. (Received September 17, 2012)

- 1086-E1-873 **Peter Olszewski*** (pto2@psu.edu), 4205 College Drive, Erie, PA 16563. *The Use of Exam Wrappers to Motivate Student Learning.* Preliminary report.

It has been observed that today's college freshmen place too much importance on achieving good grades while lacking proper metacognitive skills. There is a decided gap between how professors expect students to learn and how students actually learn. Learning how to learn is essential for success in college and life beyond. Motivated by a seminar on teaching millennials hosted by Penn State's Schreyer Institute for Teaching Excellence, I adopted Exam Wrappers in my College Algebra II class. Exam Wrappers are a series of surveys that require students to reflect on how they learn throughout the semester. Will the reflection alone help improve how students learn? In this presentation, I will share several examples of exam wrappers along with experiences regarding their effectiveness and examine the impact on learning outcomes by prompting students to reflect on how they learn. (Received September 17, 2012)

- 1086-E1-948 **Alvina J. Atkinson*** (aatkinson@ggc.edu), 1000 University Center Lane, School of Science and Technology, Lawrenceville, GA 30043, and **Barry D. Biddlecomb** and **D. Natasha Brewley**. *ACCESS (Accelerating College Completion by Enhancing Student Success) Mathematics: A Combined Developmental-College Algebra Course.* Preliminary report.

In Fall 2011, a grant was awarded to Georgia by Complete College America to produce a model that will "fast-track" learning support students through developmental courses and college algebra in a single semester. Complete College America is a nonprofit organization with the mission of increasing retention rates and graduation rates. Guiding strategies for CCA are technology-based diagnostic assessments, students to work at an accelerated rate using mastery approach, students who fall below the cut scores to concurrently enroll in college-level courses and diagnostic-based learning support, and student success skills offerings / support. The authors' institution has implemented an emporium model course. The presenters describe the model and report on its status and success. This presentation is designed for educators with an interest in innovative models in developmental mathematics. (Received September 25, 2012)

- 1086-E1-987 **Zhixiong Chen*** (zchen@njcu.edu), 2039 Kennedy Blvd, Jersey City, NJ 07305, and **Yi Ding** (yding@njcu.edu), 2039 Kennedy Blvd, Jersey City, NJ 07305. *New Strategies in Teaching Developmental Mathematics*. Preliminary report.

Teaching developmental math in urban universities is a big challenge for many math professors. This talk discusses some new strategies that we have adopted in teaching developmental mathematics from policy making to new ways of using technology. We will also delve into topics such as comparing an online tutoring system to face to face tutoring, as well as the advantages of computerized homework and testing. As the coordinator of our math department for the developmental math program for 5 years and coordinator of computer lab for more than 10 years, we will share our experience in managing multiple sections of developmental math classes and the resulting improvements in student performance. (Received September 17, 2012)

- 1086-E1-1221 **Mary D Shepherd*** (msheprd@nwmissouri.edu), 9112 County Rd 62, Savannah, MO 64485, and **Cheryl G. Malm** (cgmalm@nwmissouri.edu), 800 University, Maryville, MO 64468. *Math Skills, An Emporium Model Modified, What We Learned from the Pilot Year*. Preliminary report.

With the national trend of students entering college but not yet ready to handle a college level mathematics course, we redesigned our developmental mathematics courses using the emporium model as a base. We added more detailed reading guides and more conceptual questions to the assessments. This redesigned course was piloted during the 2011-12 school year with about 280 students and went live, with mandatory placement based on ACT scores this past fall and about 500 students. We report on what we learned during the pilot year and what we changed and are observing currently. (Received September 20, 2012)

- 1086-E1-1241 **Cheryl J. McAllister*** (cjmcallister@semo.edu), Southeast Missouri State University, 1 University Plaza, MS6700, Cape Girardeau, MO 63701, and **Pradeep Singh** and **Laurie W. Overmann**. *Improving Student Success in Developmental Algebra through a Course Redesign: Lessons Learned*.

Due to a large number of students entering a mid-size Midwestern regional university with insufficient algebraic skills, a course redesign project was undertaken utilizing technology and face-to-face tutoring to provide each student with an individualized learning experience. Data on student success, time on task, and completion rates were collected each semester to identify weaknesses in the course design. Improvements include development of a basic arithmetic course, enforcement of an attendance policy, creation of modules with short lectures to provide course structure, and assessments to develop students' mathematics organizational and communication skills. Academic advisors, campus-wide tutoring services, and disability services provided learning assistance and valuable feedback in the redesign effort. Data on students' attitudes towards the content and delivery of course materials is currently being analyzed. (Received September 20, 2012)

- 1086-E1-1416 **Susan E Thompson*** (sthompson@otterbein.edu), Mathematical Sciences Department, Otterbein University, 1 S Grove St, Westerville, OH 43081. *Flexible Options to Prepare Students for University-Level Mathematics*. Preliminary report.

Can the use of an adaptive learning system in delivering intermediate algebra to college students successfully prepare them for their university-wide mathematics requirement? Our small, private, comprehensive institution has used ALEKS [Assessment and LEarning in Knowledge Spaces], an adaptive learning system that individualizes assessment and learning, as an option for entering students to improve mathematics placement in the summer prior to matriculation for the past six years, with good success. Unfortunately, not all incoming students are able to use or complete this option due to summer work and family commitments, internet access problems, or instructional support issues. In an effort to offer this flexible, individualized instruction with technological and instructional support during the academic year, we are currently piloting use of ALEKS as the teaching/learning tool in a flexible semester option. Information presented at this session will include results from the summer offerings, including success rates in subsequent courses, and a description of the model employed for the fall semester option, with preliminary results. (Received September 21, 2012)

- 1086-E1-1815 **John W Hoggard*** (jhoggard@edinboro.edu), Edinboro Department of Math and CS, 200 Doucette Hall, 215 Meadville St, Edinboro, PA 16444. *Accelerating Development: A Pilot Bridge Program*.

This session will discuss a successful small pilot conducted this summer to help students reduce their time in our developmental mathematics program. This year, 53 percent of incoming students at Edinboro University of Pennsylvania placed into at least one remedial mathematics class. This summer, some students who achieved borderline math placement scores were invited to participate in an on-campus summer bridge program to help improve their algebra skills. Participants spent eight days working on the same Hawkes courseware used in our

basic and intermediate algebra classes, as well as receiving tutoring and attending college success workshops. At the end of the program, students were allowed to repeat the mathematics placement exam, and were able to skip at least one remedial class as a result. Although the pilot was small, it serves as a demonstration that it is possible for some students to bypass traditional remedial classes. I will discuss our developmental mathematics program, the structure of the summer bridge program, the success of the students (including performance in subsequent fall mathematics classes), and our future plans. (Received September 24, 2012)

1086-E1-2121 **Paul M Musial*** (pmusial@csu.edu), Chicago State University, Department of Mathematics and Comp. Sci., 9501 South King Drive, Chicago, IL 60628. *Shortening the Path: Condensing the Developmental Sequence into a Single Semester.*

In an effort to increase graduation rates, Chicago State University replaced a three-semester Developmental Mathematics sequence with a single semester course, with students meeting eight hours per week. We will discuss how successfully this course prepared students for college-level mathematics, whether it impacted graduation rates and retention rates, and how the University is adjusting its Developmental Mathematics model for the future. (Received September 24, 2012)

1086-E1-2309 **Angela G Vierling-Claassen*** (avierlin@lesley.edu), Cambridge, MA. *Understanding and Addressing Mathematical Shame.*

People's difficulties with mathematics often get blamed on what educators and researchers call mathematics anxiety, the fear of doing mathematics. The term "math anxiety" first appeared in the literature in the early 1970s, and was popularized by Sheila Tobias and others working in the late 1970s to address mathematical avoidance, particularly in women. The frame of mathematics anxiety has problems, however, including pathologizing mathematical difficulties and obscuring the role of community and culture. Framing difficulties in terms of shame provides a way of placing mathematical problems in a relational context. Shame is an intensely painful and disruptive emotion in which a person feels a deep-seated failure or flaw in their core self. Although shame can occur in private or in public, it is an emotion that signals a threat to our social being, and it can be characterized as feeling unworthy of human connection.

In this talk, I will discuss the impact of shame on adults and students, based on research in process that uses written memories to investigate narratives of mathematics. I will also discuss research-based methods to help developmental mathematics students investigate and re-frame their memories and become more powerful mathematically. (Received September 25, 2012)

1086-E1-2442 **Mary R Parker*** (mparker@austinctc.edu). *Statway: What worked well and how we're improving.*

Statway is a two-semester sequence to bring beginning students (ready for Elementary Algebra) to and through a college-level statistics course. Developed by the Charles A. Dana Center and the Carnegie Foundation for the Advancement of Teaching, our school and about twenty other community colleges are now offering the sequence for the second or third time. Experiences and data show that it has been very successful in terms of what the students have learned and in terms of the percentage of students who completed the sequence. This talk is about our experiences teaching it at Austin Community College and being a part of the Networked Improvement Community of colleges across the country as we refine it. (Received September 25, 2012)

Effective Strategies and Programs for Mentoring Women and Minorities in Mathematics

1086-E5-146 **Sue Geller*** (geller@math.tamu.edu). *Mentoring Women and Minorities in General Summer Programs.* Preliminary report.

There are programs that are specifically for women and/or minorities, but what about mentoring underrepresented groups in programs not specifically for them? For five years there have been four programs at Texas A&M University, sponsored on an NSF Mentoring through Critical Transitions Grant, that have been successful in encouraging women and minorities to continue in STEM fields, mostly in mathematics. This talk will emphasize the types of mentoring used, how to encourage without singling out, and a discussion of where these students went after the programs. (Received July 28, 2012)

- 1086-E5-448 **Christina Eubanks-Turner*** (ceturner@louisiana.edu), Department of Mathematics, P.O. Box 41010, Lafayette, LA 70504, and **Patricia Beaulieu**, Department of Mathematics, P.O. Box 41010, Lafayette, LA 70504. *STAGE: A pilot project in mentoring underrepresented undergraduate students*. Preliminary report.

In this presentation we give a brief overview of the program structure of the NSF-funded Smooth Transition for Advancement to Graduate Education (STAGE) for Underrepresented Students in the Mathematical Sciences. Then we will discuss effective recruitment and program implementation strategies. If time permits, we will discuss preliminary qualitative data on the effects of participation in STAGE on mathematical confidence. (Received September 02, 2012)

- 1086-E5-767 **Jessica M Deshler*** (deshler@math.wvu.edu), PO Box 6310, Department of Mathematics, 320 Armstrong Hall, WVU, Morgantown, WV 26506. *Two projects: An NSF ADVANCE mentoring program for female junior faculty members & curriculum changes to support female undergraduates in mathematics*.

This talk will describe two initiatives to support women in STEM, at the faculty and undergraduate levels.

First, West Virginia University recently received an NSF ADVANCE award through which they aim to support the success of female faculty members across campus through various programs. One program, now in its second year, involves junior female faculty members working with external mentors on clearly identified projects with specific outcomes. Some preliminary data and results from the mentoring program will be described.

Second, the talk will describe one project funded through this program which aims to increase interest among female undergraduate students in STEM through curricular and pedagogical changes implemented in a Calculus I class. The talk will describe an attempt to expose undergraduate students in mathematics courses to the ways in which mathematics is utilized in society, with the belief that increasing their understanding of the sociological and communal value of mathematics has the potential to result in increased interest and persistence in mathematics. (Received September 12, 2012)

- 1086-E5-1488 **Karen Clark*** (kclark@tcnj.edu), The College of New Jersey, PO Box 7718, Ewing, NJ 08628, and **Diane Bates**, **Elizabeth Borland**, **Lisa Grega**, **Amanda Norvell**, **Suriza van der Sandt** and **Chang Karen Yan**. *The College of New Jersey Advancement Program, or What We Did With Our NSF-Advance PAID grant*.

The College of New Jersey's Advancement Program (TAP) is a program to promote gender equity in NSF-supported disciplines, with the support of an NSF-Advance PAID grant. Since the program began in Fall 2009 the TAP team has provided support for equity through both External and Internal Mentorship Programs, regular Brown Bag lunches and Workshops, a Travel Grant program, annual Symposium, a family initiative, and assessment. The family initiative facilitated the formation of an ad-hoc collegewide committee to draft specific recommendations for providing flexibility in a faculty member's teaching load, as well as other family-friendly policies. The assessment includes collection and tracking of faculty data, work climate surveys, and qualitative interviews of full and associate professors in NSF-supported disciplines. (Received September 22, 2012)

- 1086-E5-2426 **Jerry Dwyer** (jerry.dwyer@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, **Kent Pearce*** (kent.pearce@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, and **G. Brock Williams** (brock.williams@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *Mentoring Paradigms for Underrepresented Groups in STEM Scholarship Programs*.

Since 2008, Texas Tech University has incrementally implemented a number of STEM scholarship initiatives which incorporated targeted faculty-undergraduate mentorship programs. The mentoring efforts are designed to improve scholar retention and graduation rates - especially in low socioeconomic and underrepresented student populations. We will focus on the implementation and development of these mentoring programs - specifically, the progression from traditional one-on-one, mentor-protégé models to a more collective format. (Received September 25, 2012)

- 1086-E5-2454 **Levi Johnson** (levi.johnson@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, **Kent Pearce** (kent.pearce@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, and **G. Brock Williams*** (brock.williams@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *Helping Students Engage in Successful Mentoring Relationships.*

Through our TTU PRISM and South Plains Math Scholars Programs, we connect students from under-represented groups with mentors to help them adjust to the academic environment and also to guide them toward undergraduate research. We have found engaging students in research “gets them hooked” on math and has a great effect on retention, especially for female and Hispanic students.

On the other hand, first generation students from disadvantaged backgrounds usually have no experience navigating mentoring relationships with faculty. Thus we have developed a detailed protégé training program to help students fully engage in their mentoring relationships. (Received September 25, 2012)

- 1086-E5-2484 **Anthony Tongen*** (tongenaj@jmu.edu), 800 S. Main St; MSC 1911, Department of Mathematics and Statistics, Harrisonburg, VA 22801. *M³: Mentoring, Motivation and Mancala*. Preliminary report.

For the last six years, James Madison University has held an undergraduate research program for twenty-two underrepresented minority students who are primarily at an early stage in their academic careers. Each year we have made modifications to a program that has been based on using visualization and/or experiment to emphasize mathematical concepts. We will discuss the highlights of this six-year journey along with data collected and lessons learned. (Received September 25, 2012)

- 1086-E5-2525 **Lily S Khadjavi*** (lkhadjavi@lmu.edu), Loyola Marymount University, 1 LMU Drive, Suite 2700, Los Angeles, CA 90045, and **Tanya Moore** (tanya.a.moore@gmail.com), Building Diversity in Science, 1618 Sullivan Ave. #302, Daly City, CA 94015-1967. *Promoting diversity in the mathematical sciences: the Infinite Possibilities Conference*. Preliminary report.

African-American, Hispanic/Latina, and Native American women are underrepresented in mathematics, both historically and today. According to American Mathematical Society figures from 2010, not quite a third of new doctorates were granted to women (472 of 1475), and only 26 of those were from underrepresented groups. The Infinite Possibilities Conference (IPC) aims to address this by fulfilling a need for role models and community-building; providing greater access to information and resources for success in graduate school and beyond; and raising awareness of factors that can support or impede underrepresented women in the mathematical sciences. A unique gathering, the conference brings together participants from across the country, at all stages of education and career, for mentoring and for mathematics. The conference was first held in 2005 at Spelman College but has since been co-hosted by Building Diversity in Science and each of North Carolina State University, University of California Los Angeles, and University of Maryland-Baltimore County. A description of the conference and its evolution will be presented, along with lessons learned and the immediate and broader impacts of IPC. (Received September 25, 2012)

- 1086-E5-2604 **Brian J Lindaman*** (lindaman@math.montana.edu) and **LeAnne Yenny** (leanne.yenny@gmail.com). *Math 2 Excite: Creating Interest, Confidence and Awareness about Mathematics among Young Women*.

This talk will describe a successful program designed to foster interest in math among middle school girls. Currently in its second year of funding through the MAA Tensor Foundation, the program has been shown to improve confidence in mathematical thinking and nurture a love for mathematics in the real world. There are two components to the project: a 5-day summer day-camp and an individual project. The camp consists of activities corresponding to three themes: Math in the Arts, Math in the Outdoors, and Math in Our Lives. During the summer camp, girls explore authentic mathematical applications in the world and are exposed to the use of math in various careers (such as wildlife biology and astrobology). For the individual project phase, each participant chooses a topic, collects research, writes a report, and delivers a poster presentation. The girls are mentored throughout the project phase by strong female role models: female undergraduate and graduate math students, as well as university math faculty. During this session we will discuss aspects of the program; share copies of the recruitment materials, surveys, and math camp lessons; and present a slideshow of the girls’ poster projects and camp activities. (Received September 25, 2012)

- 1086-E5-2627 **Gulden Karakok*** (gulden.karakok@unco.edu), 501 20th Street, Campus Box 122, Greeley, CO 80639, and **Brian Arthur Christopher** (brian.christopher@unco.edu), 501 20th Street, Campus Box 122, Greeley, CO 80639. *Impact of the National Research Experience for Undergraduates Programs (NREUP).*

In this presentation, we will share some results of a longitudinal evaluation of the National Research Experience for Undergraduates Program (NREUP). The NREUP is sponsored by the Mathematical Association of America (MAA) and its Strengthening Unrepresented Minority Mathematics Achievement (SUMMA) program, and funded by the NSF and the NSA. The NREUP programs are summer intensive research programs for underrepresented undergraduate students with the goal of increasing students' interest in obtaining advanced degrees and career in mathematics or a closely related field. Since its pilot year in 2003, up to 12 programs at various colleges and universities have been funded each summer. The NREUP had 410 participants since 2003, and about 46% of the participants were females. Among the participating students, 62% of them were African America, 21% were Hispanic Americans and 11% were Latino Americans. Participating students were invited to evaluate the program one, two and four years after their participation in the program. We will share results from follow-up interviews and online surveys as well as our plans to explore the experience of the program directors and mentors. (Received September 25, 2012)

- 1086-E5-2635 **Maria Lorenz*** (angelone@temple.edu) and **Irina Mitrea**. *Girls and Mathematics Summer Program*. Preliminary report.

For one week in July, we held the sixth, but first at Temple University, Girls and Mathematics Summer Program. A group of approximately 50 girls in grades 5 through 8, mostly from the city of Philadelphia, met daily and worked on interesting mathematics such as cryptography and coding. I plan to detail our program: how we organized, advertised, and ran the camp. In addition, some summary findings by a research group from Full Potential Initiative (FPI) will be presented; the study involved the Girls and Mathematics program participants and involved questions about their academic likes and dislikes, impressions of subject areas, and goals. (Received September 25, 2012)

- 1086-E5-2738 **Sandra Laursen*** (sandra.laursen@colorado.edu) and **Marja-Liisa Hassi**. *Leveling the Playing Field: Benefits for Women of Inquiry-Based Approaches in the Undergraduate Mathematics Classroom*.

Programs to mentor women mathematics students often identify women who demonstrate interest and talent for mathematics based on their performance in coursework. Yet traditional teaching approaches are known to disproportionately discourage women from pursuing further study of mathematics—filtering out women with high mathematics potential before they have opportunities for individual mentoring. We will share evidence from a large, mixed-methods study of inquiry-based learning (IBL) in college mathematics courses that suggests that IBL approaches can foster women's success. Students from IBL courses reported higher gains on self-report measures of cognitive, affective, and collaborative growth than did their peers in lecture-based courses. Yet the results show a substantial gender gap: while women reported significantly lower gains from lecture-based courses than did their male classmates, those taking IBL courses reported gains equal to their male classmates. Thus inquiry-based courses appear to close the gender gap in student gains and level the playing field for women. We will draw on other data from our study and on the literature on stereotype threat to explore reasons for this positive effect of IBL courses for women. (Received September 25, 2012)

- 1086-E5-2750 **Sheila K Miller*** (smiller@citytech.cuny.edu). *Girls Doing Research: A Case Study*.

While much attention is given to how senior faculty members and institutions can mentor young faculty members, it is our view that another significant factor in retention, particularly among minority groups and women, is the existence of a supportive peer group. In this talk we explore the concept of and provide a case study in informal peer mentorship. Through the self-guided formation of a peer network (which we called Girls Doing Research, GDR), a group of junior faculty members from various fields (all of whom were women) helped each other to maintain and develop research programs in their first years as faculty members. We present variations in our experiments (including successes and failures) and discuss how this model can be adopted by others. (See also the MAA FOCUS article by the same title.) (Received September 25, 2012)

- 1086-E5-2810 **Jerry Dwyer** and **Levi Johnson*** (levi.johnson@ttu.edu), Texas Tech University, Box 41042, Lubbock, TX 79409-1042, and **Sonya Sherrod**. *Faculty Perceptions of Mentoring Underrepresented Students*.

In 2012, researchers at a state university in the Southwest United States conducted a grounded theory examination of a number of externally funded scholarship and mentorship programs for science, technology, engineering,

and mathematics (STEM) undergraduate students enrolled at the university. Data collection methods included observations of mentoring sessions, open-ended surveys, and semi-guided interviews with STEM faculty members. The study produced a series of case studies examining the effects undergraduate mentorship had on participating faculty members. Case studies involving two of the participating faculty members provided direct insight into the impact mentorship had on faculty perceptions of and strategies for working with students from underrepresented populations. These case studies and the implications for future program development will be discussed. (Received September 25, 2012)

1086-E5-2968 **Sarah Minion*** (sminion@student.clayton.edu), **Catherine A Matos** (cmatos@clayton.edu), **Mary Hudachek-Buswell** (maryhudachek-buswell@clayton.edu) and **Scott Bailey** (scottbailey@clayton.edu), 2000 Clayton State Blvd, Morrow, GA 30260. *Supporting Women in STEM fields: The Wi2STEM Club's Evolving Impact on Student Members at Clayton State University.*

The Women Interested in Science, Technology, Engineering and Mathematics (Wi2STEM) club at Clayton State University (CSU) was formed four years ago to support female students in STEM fields. The club brings in speakers from STEM fields, funds student travel to conferences, provides job shadowing opportunities, educates members about graduate school and scholarship opportunities, and other activities. Wi2STEM is career oriented and strives to provide a supportive environment for its members and help them to achieve a school/home life balance. This is a particularly important service of the club, as a large proportion of CSU's students are non-traditional students, many with families and/or jobs outside of school.

The undergraduate presenter will report on a statistical analysis of a survey that was conducted to determine the impact of the club on its members. The influence on students will be assessed through a comparison of Wi2STEM member GPAs with the general CSU STEM population. The study will also assess student satisfaction with the club, and whether members believe that the club has facilitated their continued studies in STEM fields at CSU. Results will be compared against a survey of the general CSU STEM student population and against a study conducted two years ago. (Received September 26, 2012)

Fostering Mathematical Habits of Mind

1086-F1-82 **Holly Zullo*** (hzullo@carroll.edu) and **Christopher Storm** (cstorm@adelphi.edu). *False Confidence.*

A key step in becoming a fluent mathematical thinker is to analyze mathematical statements and to find counterexamples to false statements. We present evidence from classroom voting data collected by 10 instructors in 32 classes at 7 different institutions that suggests undergraduate students need more opportunities to develop this mathematical habit of mind. Students were more confident when voting true on a true/false mathematics question than when they were voting false, regardless of the actual veracity of the mathematical statement being considered. We will discuss this data and its implications for mathematics education. Our data was collected as part of the NSF-funded Project Mathvote. (Received July 09, 2012)

1086-F1-794 **Greisy Winicki Landman*** (greisyw@csupomona.edu), Pomona, CA 91768. *Modeling the MHoM for math majors that want to teach.*

In a capstone course for math majors that want to teach, we have as one of our goals to create appropriate learning environments that support the fostering of the Mathematical Habits of Mind. We will share several of the tasks presented to the students, their meta-analysis and some of the students' reflections as participants but also as future teachers. The tasks are diverse in the mathematical contents they rely on, their level of cognitive demand and the tools used. The Standards of Mathematical Practices - as described by the Common Core Standards - will also be highlighted in the analysis of each task. We will also discuss the students' attempts to transform a traditional textbook-oriented lesson into a MHoM oriented one. (Received September 12, 2012)

1086-F1-833 **Gary A. Harris*** (gary.harris@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, and **Raegan Higgins** (raegan.higgins@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *Fostering mathematical habits of mind in the middle school math teacher.*

We would argue that if anyone needs to practice mathematical habits of mind, it is the middle school math teacher. Here we describe our efforts to foster just that via an NSF-MSP professional development project. The primary component of our project is the delivery of three graduate-level math courses that delve deeply into

the math taught in middle school in the areas of algebra, geometry, and statistics, respectively. We will provide an illustrative example from each course. For example, in the algebra course we study the standard argument that there is no fraction whose square is 2. Then we ask, “What is special about 2.” We discover that the same argument works for any prime number, not just 2. We continue by exploring just what it means for two fractions to be equal, discovering that they must have exactly the same reduced form. This ultimately leads to our final result: The p th root of a rational number is rational if and only if the reduced form of the original rational number has perfect p powers in both the numerator and denominator (Received September 13, 2012)

1086-F1-914 **Kien H Lim*** (kienlim@utep.edu), Department of Mathematical Sciences, University of Texas at El Paso, 500 W. University Ave, El Paso, TX 79968-0514. *General and Mathematical Habits of Mind: An Overview.*

In this presentation, I will introduce habits of mind (HoM) as used by educators and related concepts in the literature and curricular documents. Costa (2000) introduces HoM as “characteristics of what intelligent people do when they are confronted with problems, the resolutions to which are not immediately apparent” (p. 21). He provides a list 16 general HoM (e.g. striving for accuracy, persisting, managing impulsivity, and thinking flexibly). In mathematics education, Cuoco et al. (1996) introduced HoM as an organizing principle for math curricula in which Grade 8-16 students think about math the way mathematicians do. Since then, different categories of HoM have been identified, including HoM for young children, HoM for arithmetic-algebraic transition, analytic and geometry HoM, and algebraic HoM. Other related concepts include ways of thinking (Harel), knowing to act in the moment (Mason & Spence), behavioral schemas (Selden & Seldon), and habits and values of mathematicians (Seaman & Szydlik). Mathematical HoM can be conceived as mathematical practices like those described in the CCSSM document. Consequently, HoM should not “be the explicit objects of our teaching, rather, each student should internalize them as they do math” (Levasseur & Cuoco, 2003, p. 34). (Received September 16, 2012)

1086-F1-940 **Amy Cohen** (acc@math.rutgers.edu) and **Jennifer V. Jones*** (jvjones@rci.rutgers.edu), CMSCE - SERC, 118 Frelinghuysen Road, Piscataway, NJ 08854. *Teachers' Use of Core Mathematical Practices.* Preliminary report.

Using some short video-clips, this presentation will discuss mid-career middle school math teachers' use of the “Mathematical Practices” advocated by the Common Core State Standards in Mathematics (CCSSM). These “core practices” include making sense, constructing and critiquing mathematical arguments, recognizing structure, and communicating with precise mathematical language. The working hypothesis is that teachers who employ these practices confidently will demonstrate their value and that children who experience the power of these practices will be more likely to adopt them for their own empowerment. The CCSSM core mathematical practices are very close to the “mathematical habits of mind” advocated by several authors and organizations. While the phrase “habits of mind” may suggest internal mental states, the word “practices” may suggest something more active and public. Nonetheless, the goal in both cases is to support active engagement in learning and in doing mathematics. (Received September 20, 2012)

1086-F1-1065 **Randall E Cone*** (conere10@vmi.edu), 439 Mallory Hall, Virginia Military Institute, Lexington, VA 24450. *The Open Math Lab: Building an IBL-Based Tutoring Center.*

Inquiry-Based Learning (IBL) is an approach to teaching that focuses on student-centered activities, oftentimes occurring in the classroom, which are designed to facilitate active learning. In the context of mathematics teaching, many of these activities are explicitly crafted to foster Mathematical Habits of Mind (MHoM). Due to an overwhelming need on the behalf of our institution's students, we began the process two years ago of creating a new tutoring facility entirely dedicated to mathematics. After a careful and thoughtful design process, the Open Mathematics Laboratory (OML) was established, with IBL as its pedagogical foundation. Three major questions surrounding the above processes are discussed in this presentation: what precisely are the IBL-based underpinnings for the OML? What are the day-to-day challenges that students and tutors experience in the OML? How has the OML been received by students, faculty, and administrators? (Received September 18, 2012)

1086-F1-1097 **Martin E Flashman*** (flashman@humboldt.edu), Department of Mathematics, Humboldt State University, Arcata, CA 95521. *The Benefits of A Habit: Examining Evidence to Understand Statements and Proofs.* Preliminary report.

After having taught bridge courses with many different texts and organizations, the author has evolved an approach that recognizes that students can benefit in their first steps in composing a proof by developing a habit of examining evidence to understand the problem before attempting to plan a proof. The author will provide examples and clarification of how developing this habit has changed his approach both in and out of the class

room. This work is based in part on Daniel Solow's texts "The Keys to Advanced Mathematics..." and "How To Read and Do Proofs" as well as G. Polya's classic, "How To Solve It." (Received September 18, 2012)

1086-F1-1399 **Jennifer Szydlik, Eric Kuennen, Jason Belnap and Amy Parrott*** (parrotta@uwosh.edu), UWO Mathematics Department, 800 Algoma Blvd, Oshkosh, WI 54901, and **Carol Seaman**. *Conceptualizing and Measuring Mathematical Sophistication*.

In this talk, we elaborate a framework to define, and a paper-and-pencil instrument to measure, the mathematical sophistication of prospective elementary teachers. We call an individual mathematically sophisticated if her values and practices reflect those of the mathematical community on nine interwoven categories involving patterns, conjectures, structure, definitions, examples and models, relationships, arguments, language, and notation. We describe the Mathematical Sophistication Instrument we developed and report the results of our study of its reliability, validity, and capacity to measure changes. We hope that the instrument provides educators a tool for assessing programs designed to nurture Mathematical Habits of Mind. (Received September 21, 2012)

1086-F1-1594 **Charlene Morrow*** (cmorrow@ntholyoke.edu). *Mathematical Habits of Mind (MHoM) Are Not Just for Math Class: Using Mathematical Ways of Thinking Outside the Mathematics Classroom to Create Artwork*.

Goldenberg, Cuoco, and Mark, in 1996, claimed that MHoM could be an organizing principle for high school curricula to help close the gap between what the users and makers of mathematics do and what they say. They state that high school mathematics should help students: 1) become comfortable with fuzzy problems; 2) see the benefit of systematizing and abstraction; 3) develop ways of describing situations; and 4) develop genuinely mathematical ways of thinking. There are also many problems in realms not usually defined as mathematical in which MHoM can spur creativity. We often talk about ways that mathematics can help solve a number of practical life problems, but most people never give mathematics a thought when working in more creative/artistic realms. We can measure the size opening for a mat once we have finished a painting, but what about bringing mathematics into the picture when creating a painting? If mathematical thinking is truly habitual, i.e., part of our skill set, then MHoM can contribute to our approach to any problem in any area. I will argue that students are more willing to develop MHoM if they believe that these habits will be useful outside of the mathematics classroom. I will also describe how I used mathematical thinking to create a series of artworks. (Received September 23, 2012)

1086-F1-1621 **Sarah E. Bell*** (sb519799@sju.edu), 189 Osborn St., Philadelphia, PA 19128, and **Josh Bargiband** (jb488519@sju.edu) and **Tetyana Berezovski** (tberezov@sju.edu). *Investigations in mathematics teacher education: the role of personal reflection as a learning instrument in mathematics classes for teachers*.

At Saint Joseph's University in the summer 2011, a geometry course was conducted for secondary mathematics teachers to develop and refine the knowledge and skills needed for the teaching of geometry. Our study attempts to demonstrate the effectiveness of reflecting on mathematical tasks; namely, how the reflective process relates to the growth in Mathematical Knowledge for Teaching (MKT; Hill; Schilling; Ball 2004). We develop a framework for analyzing the teachers' reflections in correlation with the change of their MKT that was assessed by pre-posttest. The assessment instrument included questions from the Graduate Record Examinations (GRE) and the National Assessment of Educational Progress (NAEP). The framework proved to be effective in studying the connection between the reflective process of mathematics teachers and their change in MKT. (Received September 24, 2012)

1086-F1-2344 **Erica Slate Young*** (erica.slate@uah.edu). *Finding Ways to Evaluate Students' Development of Mathematical Habits of Mind*.

This paper will focus on not only my teaching philosophy and how it relates to fostering MHoM, but also on the lessons I've learned in my recent research efforts in implementing technology in math education settings. Put briefly, my teaching philosophy is this: In my class, the answer is worth very little; the solution is what is truly important. I want my students to understand the mechanics behind the skills they are learning, to understand a mathematical problem solving process necessary to answer complex questions and then, when appropriate, use technology to help find solutions. In my recent research, I have found the following system useful in evaluating student work. I ask, can they: find appropriate simplifications and approximations that allow the model to mimic the real system in an acceptable way; identify a complete enough set of variables and parameters to describe the system non-trivially; identify the governing principles: physical laws & empirical knowledge; choose the proper level of mathematical complexity; identify the satisfactory solution; visualize the solution in some

way, revise the model if the solution doesn't match reality? I believe this framework could help others reflect on whether or not, and the degree to which their students are developing MHoM. (Received September 25, 2012)

- 1086-F1-2444 **Brian P. Beaudrie*** (brian.beaudrie@nau.edu), 805 South Osborne Dr, P. O. Box 5717, Department of Mathematics and Statistics, Flagstaff, AZ 86011. *Mathematical Habits of Mind in the "Making the Transition from High School to College" Project.*

This paper will discuss the use of the Mathematical Habits of Mind in the "Making the Transition from High School to College" project, a Math-Science Partnership funded project for which the author was a Project Director.

As part of this project, a list of MHOM were created (based on Costa's and Kallick's 16 Habits of Mind). These MHOM, their meaning, and how to incorporate them into the classroom, were presented to teachers during a summer workshop.

As the academic year progressed, teachers were given continued support, (in face to face meetings and via the internet) to help them build their understanding on how to incorporate MHOM into their mathematical thinking and (eventually) their teaching. Teachers were asked to work on various problems; after solving them, they would discuss the mathematics behind them, and the various MHOM brought to bear in the problem. There were also research presentations that showed how other teachers were successfully using the MHOM in their classroom, along with the positive changes in performance that resulted.

This presentation will discuss how incorporating the MHOM allowed the teachers to begin, as one put it, "to change the culture of our classroom"; essentially changing what they and their students believed about math. (Received September 25, 2012)

- 1086-F1-2465 **Steven R. Benson*** (sbenson@lesley.edu), Division of Natural Sciences and Mathematics, Lesley University, 29 Everett St, Cambridge, MA 02138. *Ways to Think About Mathematics: A Habits of Mind Approach for Teachers and other Mathematicians.* Preliminary report.

Starting with problems having low thresholds and high ceilings, we encourage collaborative exploration, giving students the time to ponder, experiment, conjecture, and construct their own careful mathematical justification for their claims. This problem-centered approach gives students the opportunity to actually do mathematics by thinking like a mathematician, thus providing a model for teachers working with their own students. Though the model and materials were initially developed with preservice and inservice teachers in mind, we have been successful in using the approach in upper level mathematics courses for all students. Experience, recommendations, and resources will be shared. (Received September 25, 2012)

- 1086-F1-2547 **Jennifer M. Lewis*** (jmlewis@wayne.edu), 223 College of Education, 5425 Gullen Mall, Wayne State University, Detroit, MI 48202, and **Davida Fischman.** *Developing Measures for Teachers' Mathematical Habits of Mind.* Preliminary report.

This paper describes the development and use of a pair of instruments, a newly conceived MTEBI (Mathematics Teacher Efficacy and Beliefs Instrument) and the Mathematics Teaching Habits of Mind (M-THoM), designed to describe and document teachers' sense of self-efficacy, outcomes expectancy, and habits of mind specific to the teaching of mathematics. These instruments were developed around the strands of mathematical proficiency (Kilpatrick, Swafford, & Findell, 2001) and the standards for mathematical practice from the Common Core State Standards (National Governors Association Center for Best Practices, Council of Chief State School Officers 2010), and informed by various theoretical and practical studies of habits of mind (Charbonneau, Jackson, Kobylski, Roginski, Sulewski, & Wattenberg, 2009; Costa, & Kallick, 2008; Ennis, 1986; Goldenberg, 1996; Perkins, Jay, & Tishman, 1997). We report on data collected from a pilot study using these newly developed instruments, and give rationale for their development. (Received September 25, 2012)

- 1086-F1-2607 **Tamas Szabo** (szabot@uww.edu), 800 W Main St, Department of Mathematics, Whitewater, WI 53190, and **Craig Snider*** (SniderCW14@uww.edu), University of Wisconsin Whitewater. *Developing Mathematical Habits of Mind in a Problem Solving Course for Preservice Middle School Teachers.* Preliminary report.

A new course "Problem Solving for Teachers" has been created at the University of Wisconsin Whitewater to foster mathematical habits of mind. We will discuss the successful (and unsuccessful) pedagogical methods that have been tried, and share some evidence of students thinking differently by the end of the course. Although the course has only been taught for two semesters, some preliminary results indicate that taking it improves future teachers' success rates in other mathematics courses. (Received September 25, 2012)

- 1086-F1-2618 **David D Barker*** (dbarker@ilstu.edu), Department of Mathematics, Illinois State University, Normal, IL 61790-4520, and **Saad El-Zanati** (saad@ilstu.edu), Department of Mathematics, Illinois State University, Normal, IL 61790-4520. *Research Experiences for Teachers: Developing Mathematical Habits of Mind for Teaching.*

The development of mathematical habits of mind is an important component in the preparation of secondary mathematics teachers. One avenue to developing mathematical habits of mind is to involve future teachers in mathematics research. Unfortunately, preservice teachers rarely receive this opportunity. The Research Experiences for Undergraduates (REU) Site for Secondary Mathematics Teachers at Illinois State University was designed in response to the national need for highly qualified mathematics teachers and the call for prospective mathematics teachers to experience mathematics research. The goals of the program are to expand the prospective and practicing mathematics teachers' views of mathematics as a dynamic endeavor, to provide opportunities for mathematical discovery, to improve their mathematical habits of mind, and to enhance their content and pedagogical content knowledge. This presentation will describe the REU program, sample research problems, components designed to develop mathematical habits of mind and to help teachers' translate their research experience to the classroom, and suggestions for implementation. In addition, data will be provided that characterizes the changes in their beliefs about mathematics as a result of experiencing mathematics research. (Received September 25, 2012)

- 1086-F1-2657 **Sherry L Hix*** (slhix@northgeorgia.edu) and **Dianna J Spence.** *Using the Standards for Mathematical Practice from the Common Core to Develop Mathematical Habits of Mind in Pre-service Teachers on the College Campus and in Secondary Field Experiences.* Preliminary report.

We examine the Common Core Standards for Mathematical Practice in order to develop mathematical habits of mind in our undergraduate pre-service secondary mathematics teachers. To fulfill their required program of study, these students engage in a three-part iteration: They explore open mathematical tasks; they ascertain facets of the task itself that develop good mathematical practices; and they determine specific "teacher moves" intended to further develop good mathematical practices. This work takes place during two courses: Mathematics Methods & Materials and Mathematics Curriculum.

A field experience component is included with these courses. During this field experience, the pre-service secondary mathematics teachers must complete a similar three-part iteration for their observations of mathematical work that take place in the secondary school placement.

These practices help our pre-service secondary mathematics teachers enhance their own mathematical habits of mind, while also focusing on strategies to develop those habits in their students. (Received September 25, 2012)

- 1086-F1-2670 **Hsing Wen Hu*** (hhu2@uaa.alaska.edu), 3211 Providence Drive, Professional Studies Bldg., Anchorage, AK 99508, and **Cheng-Yao Lin** (cylin@siu.edu), 625 Wham Drive, Mail Code 4610, Carbondale, IL 62901. *An Instructional Model for Learning Division of Fractions and Fostering Learner's Mathematical Habit of Mind.* Preliminary report.

Developing learners' Mathematical Habits of Mind provides a way for math educators to deepen learners' conceptual understanding. Even if these habits are used randomly. A study is being conducted to investigate an instructional model for teaching division of fractions. This model may foster learners' Mathematical Habits of Mind. It also provides learners with the opportunity to perceive division problems of fractions. This is done through conveying concept with different representations and demonstrating connections between these representations. Then the learner's natural dispositions (Mathematical Habit of Mind) may be developed or exposed through purposeful procedures and continue reflections during the instruction. Our practices suggest that using organized mathematical instructions with perception of incorporating Mathematical Habits of Mind provides the optimal setting for learners to construct their conceptual understanding in the learning division of fractions. Furthermore, they are more comfortable using desirable Mathematical Habits of Mind to think of mathematics. (Received September 25, 2012)

History of Geometry, Its Applications, and Their Uses in the Classroom

1086-F5-613 **John Donnelly*** (jrdonnelly@usi.edu), 8600 University Blvd., Evansville, IN 47712.
Triangle Congruence in Absolute Plane Geometry.

Plane geometry has a long and rich history dating back thousands of years to the time of Euclid and the ancient Greeks. Throughout the years, plane geometry has had numerous applications in engineering, the sciences, as well as other branches of mathematics.

Absolute Geometry is plane geometry in which we assume no parallel postulate. Absolute Geometry can be thought of as being a common ground between Euclidean Geometry and Hyperbolic Geometry. There are several criteria that one can use in Absolute Geometry to determine whether or not two triangles are congruent. For example, one can use the Side-Angle-Side, Angle-Side-Angle, Side-Angle-Angle, and Side-Side-Side criteria for congruence of triangles.

The speaker will give a brief history of Absolute Geometry, and then examine the various relationships between the criteria for triangle congruence. We will then state some recent results about these criteria and their relationships with one another. (Received September 09, 2012)

1086-F5-620 **Thomas Drucker*** (druckert@uww.edu), Dept. of Mathematical and Computer Sciences, University of Wisconsin–Whitewater, Whitewater, WI 53190. *Applications of Geometry in the Philosophy Classroom and Beyond.* Preliminary report.

Geometry as presented in Euclid's Elements has served as a model for the presentation of philosophical ideas through the millennia. Even before Euclid, Plato wanted to keep those ignorant of geometry out of the Academy. What is it about geometry that makes it especially appealing to philosophers in expounding their subject? This talk will seek to answer that question in the time of Plato and then in the seventeenth century in the work of Descartes, Spinoza, and Leibniz. The discussion will conclude with an examination of the effects of changes in the geometry curriculum in the schools in the role the subject can play in presenting philosophy. (Received September 09, 2012)

1086-F5-638 **James J Tattersall*** (tat@providence.edu), Department of Mathematics, 549 River Avenue, Providence, RI 02918. *Steiner-Lehmus revisited - again.* Preliminary report.

In 1840 C.L. Lehmus, professor of mathematics at a military engineering school in Berlin wrote to Charles-François Sturm at the École Polytechnique in Paris asking him if he could provide a proof the following conjecture: If BOD and COE are equal bisectors of the base angles of triangle ABC , then AB equals AC . Sturm passed the query on and in 1844 Jacob Steiner professor of geometry at the University of Berlin published the first proof of the conjecture. In 1852 J.J. Sylvester produced two more indirect proofs and questioned the existence of a direct proof. By 1940 over sixty (mainly indirect) proofs of the conjecture had appeared in print. We discuss techniques used to establish the result and the complications encountered in constructing a direct proof. (Received September 10, 2012)

1086-F5-871 **Meighan I. Dillon*** (mdillon@spsu.edu), SPSU, Mathematics Department, 1100 S. Marietta Pkwy SE, Marietta, GA 30060. *The History of Motion in Geometry.* Preliminary report.

Pappus's proof of the congruence of base angles in an isosceles triangle is much shorter and cleaner than Euclid's proof. We know from The Elements that Euclid was a master proof-writer. Why would he have missed Pappus's proof? We can never know the answer to that question, but one possible problem with Pappus's proof is that it seems to involve moving a triangle. Motion was off-limits in geometry until late in the 19th century. Once Klein and Lie brought groups into the picture, though, geometers had a means for dealing with motion formally and geometry changed for good. This talk is a brief history of the role of motion in geometry, why it had to stay out for so long, how it got in, and what happened once it did. (Received September 14, 2012)

1086-F5-1030 **Peggy Aldrich Kidwell*** (kidwellp@si.edu), MRC671, NMAH, Smithsonian Institution, P.O. Box 37012, Washington, DC 20013-7012. *Pleasure, Pedagogy and Performance for an American High School Geometry Teacher – The Dissected Polyhedra and Polygons of A. Harry Wheeler.* Preliminary report.

In the first half of the twentieth century, the American high school mathematics teacher Albert Harry Wheeler (1873-1950) designed and built a collection of hundreds of geometric models. His models embodied earlier developments in the study of polygons and polyhedra, and represented novel advances in this area. He met and corresponded with eminent figures. However, in choosing what models he designed, made and used, Wheeler was

more interested in pursuing his own notion of aesthetics and mathematical correctness, and in issues of pedagogy and in public performance, than in following the demands of the larger mathematical profession. David Lindsay Roberts has examined his career as it illuminates the structure of the American mathematical community in the early twentieth century. Here I consider his work in one area – the dissection of polygons and polyhedra – as it reflects contemporary geometry and geometry teaching, Wheeler’s personal concerns, and popular recreations of the day. (Received September 18, 2012)

1086-F5-1394 **George W. Heine*** (gheine@mathnmaps.com). *Euler and the Figure of the Earth.*

The debate between followers of Newton and Cassini in the early 1700s, about whether the earth is a spheroid flattened at the poles (oblate) or flattened at the equator (prolate), forms one of the more colorful chapters in the history of mathematics. The French Academy sent measuring teams to the “ends of the earth”—Lapland and Ecuador—and their results seemed to resolve the controversy, although doubt still lingered.

Leonhard Euler, in a 1754 presentation to the Berlin Academy (E215, *Elémens de la Trigonométrie Sphéroïdique, Tirés de la Méthode des Plus Grands et Plus Petits*), summarized current results and set forth his own estimates of the shape of the spheroid. We review the context of Euler’s work, and analyze his methods and conclusions in the light of contemporary theory. (Received September 21, 2012)

1086-F5-1470 **Christopher Goff*** (cgoff@pacific.edu). *Diophantine Geometry, Eulerian Number Theory, and Undergraduates.* Preliminary report.

This talk will tell the story of how a geometry problem of Diophantus led all the way to a paper of Euler on number theory. Then we will describe how translating this work of Euler led ultimately to an undergraduate project in a History of Mathematics course last spring. (Received September 22, 2012)

1086-F5-1649 **Toke L Knudsen*** (toke.knudsen@oneonta.edu), Department of Mathematics, SUNY Oneonta, 108 Ravine Parkway, Oneonta, NY 13820. *The Constructive Geometry of the Śulbasūtras.*

The oldest systematic presentation of mathematics in India is found in the texts known as the *Śulbasūtras*, “Rules of the Cord,” generally dated to 800–200 BCE. Appendices to ritual texts, they provide the mathematical knowledge necessary for measuring out arenas and constructing brick altars for various sacrifices. Included in this body of knowledge is the practical construction of geometrical figures, combination of geometric figures, and transformation of a figure to another figure of the same area (including transforming a square into a circle and a circle into a square). That the geometry of the texts is meant for practical constructions links it to its historical context and is therefore a fruitful example for the classroom. The talk will discuss the geometry of the texts, its practical execution, and its historical context. (Received September 23, 2012)

1086-F5-2213 **Sarah L Mabrouk*** (smabrouk@framingham.edu), Framingham State University, Mathematics Department, 100 State Street, PO Box 9101, Framingham, MA 01701-9101. *A Wiki, Some Geometry, and the Parallel Postulate.*

In the study of geometry, consideration of the parallel postulate provides a wonderful example of the questioning, exploration, and development of mathematical ideas. Consideration of Euclid’s avoiding using his fifth postulate until his examination of the twenty-ninth proposition in the *Elements*, the belief of various mathematicians including Legendre that this statement was not a true postulate and their spending numerous years trying to prove it, Klügel’s analysis of twenty-eight alleged proofs of the parallel postulate in his 1763 dissertation, and the development of equivalent statements to the parallel postulate add depth to the study of Euclidean geometry and naturally lead to the study of other geometries in which this postulate holds or does not hold. In this presentation, I will discuss my use of a wiki to facilitate my students’ exploration of the development of Euclidean geometry and its history as well as the how the consideration of the parallel postulate lead to investigation of non-Euclidean geometries. I will share student reaction to the use of the wiki as well as some aspects of their consideration of the history of geometry and the examination of the parallel postulate that students found to be particularly fascinating or inspiring. (Received September 25, 2012)

1086-F5-2403 **Stacy G. Langton*** (stacy.g.langton@gmail.com), Dept. of Mathematics and Computer Science, University of San Diego, 5998 Alcalá Park, San Diego, CA 92110. *Albert Girard’s Iterative Method for solving Cubic Equations.* Preliminary report.

In 1629, Albert Girard (1595–1632) published a pamphlet, *New Discoveries in Algebra*. The contents of this work range from basic arithmetic to the theorem that the coefficients of a polynomial equation are (what we call) the elementary symmetric functions of the roots. In the course of a discussion of cubic equations, Girard gives an iterative method for solving certain cubic equations numerically. “Here,” he says, “is a small rule using Tangents and Sines, wonderful in its operation and easy to use.” Girard gives no derivation or proof of his method, only

a numerical example and a geometrical diagram. In this talk, I will show how to interpret Girard's diagram, so as to explain and justify his algorithm. (Received September 25, 2012)

How Assessment Results Changed our Program

1086-G1-1888 **Sherry L Hix*** (slhix@northgeorgia.edu) and **Dianna J Spence**. *Closing the Loop: How Creating and Administering Assessments for NCATE / NCTM Program Recognition Directed Us to Data Analysis that Improved our Program*. Preliminary report.

In order to align our undergraduate program in secondary mathematics with NCTM program standards, we designed several assessments. Two of these revealed weaknesses, resulting in significant program changes.

One assessment is a portfolio assignment in our senior seminar course, focused on seven strands of mathematical content. This assessment revealed that students were not fully prepared for the statistics and data analysis necessary to teach high school. As a result, the seminar course was enhanced to provide greater emphasis in this area, and additional elective coursework in statistics was strongly recommended for students in the program.

Another assessment is a rubric used to evaluate student teaching. This assessment revealed a lack of pedagogical content knowledge as our students designed and implemented mathematics lessons in the field. To address this deficiency in mathematical knowledge, a Mathematics Curriculum course was developed in the Mathematics department to replace a generalized curriculum course that students previously completed in the Education department.

The discussion of these changes in course requirements and course design will reflect how the assessments have improved student learning and, by extension, future teaching in mathematics. (Received September 24, 2012)

1086-G1-1908 **James Hamblin*** (jehamb@ship.edu), 1871 Old Main Drive, Shippensburg, PA 17257. *Making Assessment Meaningful*.

Many departments struggle with how to make assessment meaningful for their faculty members. At Shippensburg we have a robust assessment program for our math major, and we use assessment data to inform curriculum decisions. I will discuss how the program was developed and how the data we collect help us improve both the curriculum and the assessment program itself. (Received September 24, 2012)

1086-G1-2015 **Yu-Ju Kuo***, yjkuo@iup.edu, and **Frederick Adkins**. *From assessment to a mathematics-focus NSF S-STEM program*.

In preparing to write a NSF S-STEM proposal, data was collected to assess degree programs in the College of Natural Science and Mathematics at Indiana University of Pennsylvania. Our goal was to build a scholarship cohort focused on applied mathematics consisting of junior and senior undergraduates in science and mathematics and graduate students in the M.S. in Applied Mathematics program. In addition to demographic data and the number of graduates in specific degree programs, we tracked each student's progress for 4 years starting Fall 2005. This allowed us to recognize that a retention issue occurs during students' early college years. We also analyzed financial need distribution to determine amounts that would provide significant impact on retention and academic performance. After the scholarship cohort started in Fall 2010, we were baffled by the low number of minority applicants to the scholarship program. From further analysis we determined that the number of minority students meeting the financial need and GPA requirements was extremely low. This resulted in a modification of the application requirements for our renewal proposal. In this presentation, we will share our data and additional modifications to our S-STEM program resulting from program assessment. (Received September 24, 2012)

1086-G1-2099 **Barbara Moskal*** (bmoskal@mines.edu) and **Lyndsey Wright**. *A Comprehensive Assessment Program*.

All effective collegiate assessment programs share certain characteristics: quantitative data collection, well-defined goals, and adjustment when a goal is not met. Some assessment programs, however, reach further. The assessment of our Mathematical and Computer Sciences Department (MACS) has over the last 15 years evolved to include much more than just the basic standards.

Our program has collected quantitative data in the form of exam and assignment grades. We have also collected qualitative data in the forms of surveys (student and faculty), focus groups and exit interviews. This extra data has led to revisions within and outside of the MACS department. Examples include collaboration with the Physics Department and the development of a joint program with another college to offer a requested new minor. We assess both the undergraduate and graduate programs.

More importantly, our assessment program assesses itself. We seek external feedback, which led to our participation with SAUM. We also compare our program against ABET standards. We qualitatively self-analyze our assessment methods, which has led to four major program revisions. The proposed presentation will describe in further detail our methods and the outcomes we've seen. (Received September 24, 2012)

1086-G1-2516 **Jonathan Rogness*** (rogness@math.umn.edu), **Harvey Keynes** (keynes@math.umn.edu), **Jane Butterfield** (butter@umn.edu) and **Justin Sukiennik** (jesukien@colby.edu).

Reducing the Gender Gap on a Qualifying Exam. Preliminary report.

The University of Minnesota Talented Youth Mathematics Program is a five-year accelerated program for middle and high school students, ranging from algebra through University honors level courses in linear algebra and vector calculus. Admission is based largely on scores on a 50-question, 20-minute entrance exam which assesses computational, number reasoning and spatial reasoning skills. The test has been very accurate in identifying students who can succeed in the program, but females have consistently earned lower scores than males. We analyzed both the structure and content of the exam to determine whether this difference was due to selection bias in our applicants or a gender bias in the exam. This resulted in relatively minor changes in the structure and content of the exam which essentially eliminated the gender bias on one version of the 2012 entrance exam, increasing the percentage of females who qualified. When we reverted those changes for a later testing date, the gender gap returned. We will discuss these outcomes and explore several possible explanations. We will also indicate plans for possible refinements in future testing. Although some of our conclusions apply most directly to middle school aged students, other aspects may be relevant to testing at all levels. (Received September 25, 2012)

1086-G1-2654 **Alex Heidenberg*** (alex.heidenberg@usma.edu), **Jerry Kobylski** and **Rod Sturdivant.** *Assessment 2.0; SAUM meets Accreditation.* Preliminary report.

SAUM provided an excellent opportunity for the United States Military Academy to look at its assessment program, learn from other institutions involved in the grant and make adjustments to its procedures. The most recent visit from the Middle States Commission on Higher Education made us rethink our program of assessment. Although we had established goals, collected data, and closed the loop by looking at our data and making necessary changes, our procedures were not formalized. Over the last two years we have refocused our efforts into writing clear measureable objectives. We have formalized the collection of this data and created a long range plan of which goals would be assessed each year. Our talk would discuss our new goals and outcomes, our plan to assess these goals and outcomes, and the changes that we have made thus far. (Received September 25, 2012)

1086-G1-2819 **Thomas R Hagedorn*** (hagedorn@tcnj.edu), Department of Mathematics and Statistics, The College of New Jersey, P.O. Box 7718, Ewing, NJ 08542. *How We Stopped Worrying and Learned to Love Assessment: One Department's Story.* Preliminary report.

From 2004-06, a team of three mathematics and statistics faculty members from The College of New Jersey participated in the MAA's PREP/SAUM workshops. These faculty helped the department develop learning outcomes and goals for its mathematics, statistics, and mathematics education majors and develop a plan for program assessment. Since the initial development of an assessment plan, the department has engaged in a series of assessment efforts, including a year-long program review with external evaluators.

This talk will review both the achievements of these assessment efforts and the challenges still remaining. Not all our efforts have been equally successful, but regular assessments of our program through a variety of informal and formal methods, have led to significant changes such as introducing a new academic major and improving our advising support system. (Received September 25, 2012)

1086-G1-2822 **Sarah E. Eichhorn*** (sfrey@math.uci.edu), 340 Rowland Hall, UC Irvine Mathematics Department, Irvine, CA 92697, and **Tommy Occhipinti** (tocchipi@uci.edu), 340 Rowland Hall, UC Irvine Department of Mathematics, Irvine, CA 92697. *Five Years of Math Programmatic and Course Assessment at UC Irvine.* Preliminary report.

UC Irvine began an assessment of our undergraduate majors five years ago as part of our accreditation review process. We now have several years of student performance data on a skills based exit exam. In the intervening years, we have made changes to our major based on that assessment data. In this talk, we will discuss our decision to require an introductory proof course and the resulting effect on our student performance.

We have also recently implemented pre and post mathematical reasoning skills tests for several of our key math courses. Preliminary results on student learning growth in these courses will be shared. (Received September 25, 2012)

Innovative and Effective Ways to Teach Linear Algebra

1086-G5-20 **Ronald L Merritt*** (ronald.merritt@athens.edu), Mathematics and Computer Science, 300 North Beaty Street, Athens, AL 35613. *A comparison between online and traditional delivery models for an undergraduate course in elementary linear algebra.*

Every mathematics and mathematics education major enrolled at Athens State University must successfully complete a standard undergraduate course in linear algebra. Since the summer of 2010, this course has been offered to students in online and traditional face-to-face delivery formats. Students enrolled in either course must take major tests or final examinations proctored by their instructor, but other assessments, delivery of course content and most of the interaction among the students and the instructor for the online group primarily take place via electronic means. This paper compares student performance between 4 traditionally delivered sections with 3 electronically delivered sections over a four-year period (2008-2012). In addition, this paper addresses the attempts to make the course delivery and formative assessments as congruent as possible, thus enabling students to meet the same course objectives regardless of delivery mode. (Received July 26, 2012)

1086-G5-126 **Garret E. Sobczyk*** (garret_sobczyk@yahoo.com). *The Spectral Basis of a Linear Operator.*

The idea of a spectral basis first arises in modular or clock arithmetic but is an even more powerful tool in linear algebra and numerical analysis. The spectral basis of a linear operator, uniquely determined by its minimal polynomial, exhibits the macro structure of a linear operator in terms of the basic building blocks of mutually annihilating idempotents and nilpotents which determine its generalized eigenspaces. These ideas are only part of a much larger program developed by the author in his new book, "New Foundations in Mathematics: The Geometric Concept of Number" (Birkhauser 2012), which uses geometric (Clifford) algebra to present an innovative approach to elementary and advanced mathematics. Starting with linear algebra, geometric algebra offers a simple and robust means of expressing a wide range of ideas in mathematics, physics, and engineering. (Received July 26, 2012)

1086-G5-432 **Daniel A Ramras*** (ramras@nmsu.edu). *The Wronskian as a method for introducing vector spaces.*

One challenge in most linear algebra classes is the jump from R^n to the general notion of a vector space. I'll discuss a method for introducing vector spaces that focuses on the example of real-valued function spaces. These are different enough from R^n to be new and interesting, yet concrete and familiar enough for students to explore on their own with the proper guidance. I'll describe a method helping students discover various ideas like linear combinations, linear independence, and linear transformations in the context of function spaces, culminating in Wronskian matrix and its application to independence of functions. (Received September 01, 2012)

1086-G5-456 **Dan Seth*** (dseth@wtamu.edu), Department of Math, Chemistry and Physics, WTAMU Box 60787, Canyon, TX 79016. *The incorporation of weekly laboratory explorations with MATLAB in the Linear Algebra Curriculum.* Preliminary report.

The MATLAB program has been integrated into undergraduate Linear Algebra at WTAMU the past 5 years. The course has been taught in a computer classroom. However, the plethora of software and on-line sites is increasingly a distraction to learning. Beginning fall 2011 the class format was modified to include a weekly lab in a computer classroom with the other days in a "smart" classroom. Friday labs include: solving systems of equations with MATLAB, balancing chemical equations, linear combinations and rank, visualizations of spanning space and vector or matrix norms, DE's and linear algebra, diagonalization, and least squares. Classroom attentiveness, retention and the comprehension of theoretical concepts have improved. Students like the lab format and have indicated it helps them learn. We will discuss the format change, address effective enhanced learning through technology labs, and present a cool lab or two. (Received September 03, 2012)

1086-G5-841 **Andrew J Simoson*** (ajsimoso@king.edu), King College, Mathematics Department, 1350 King College Road, Bristol, TN 37620. *Tracking the transit of Venus.*

Every 120 years or so, Venus crosses directly in front of the Sun with respect to the Earth, a phenomenon that Halley in 1716 realized could be observed, whereupon the time lapses for Venus's shadow to cross the Sun from two widely separated, north to south, vantage points on Earth would be enough to quantify the actual length of an astronomical unit, the distance between the Sun and the Earth. Using linear algebra in a CAS setting, we dynamically model this motion and subsequent analysis, making plentiful use of inverse, projection, and rotation matrices—all in all providing a nice application example for the linear algebra classroom. (Received September 13, 2012)

- 1086-G5-911 **Draga Vidakovic*** (dvidakovic@gsu.edu), **Sergio Loch**, **William Martin**, **Jeff Suzuki**, **Laurel Cooley** and **Scott Dexter**. *LINE: Linear Algebra in New Environments – Focusing on Students’ Learning*.

Ten mathematicians and mathematics education researchers are studying ways to incorporate research on the teaching and learning of mathematics to shape instruction in upper division undergraduate linear algebra courses. Over two years, ten sections of undergraduate linear algebra were taught at four institutions implementing modules that were based on the APOS learning theory. Our presentation will examine the impact of the use of these modules on more than 150 students and their instructors. We analyzed student learning based on written work, student and instructor interviews and reflections, and classroom observations. Our analysis of these data indicates that the most affected students were prospective mathematics teachers. They reported increased awareness of the importance of attending not only to the mathematical content, but also their students’ ways of learning mathematics. Participants demonstrated significant awareness of how they learned mathematics. (Received September 15, 2012)

- 1086-G5-1206 **Sang-Gu Lee*** (sglee@skku.edu), Department of Mathematics, Sungkyunkwan University, Suwon, 440-746, South Korea, and **Kyung-Won Kim**. *Sage E-books on Linear Algebra and Calculus*. Preliminary report.

Calculus and Linear Algebra are arguably the most popular math subjects in colleges. We believe that students’ learning and understanding of these subjects can be improved substantially if we incorporate the latest advanced information technologies in our teaching. Our experiences indicate that CAS tools can be used to improve student’s ability in solving real world problems. In particular, we found that the open source mathematics program ‘Sage’ (<http://sagemath.org>) can be a good candidate to achieve our goal of improving students’ interest and learning Calculus and Linear Algebra. To develop a systematic program of incorporating information technologies into our teaching curriculum, we have (i) developed (and used in class) a Laboratory Manual for Calculus with Sage, (ii) developed e-book for i-Pad in order to maximize the use of its contents and (iii) developed a Linear Algebra with Sage Textbook that has several interesting features such as QR codes to pre-made movie clips of each lecture and QR codes to customized Sage single cells with ready-made Sage codes.

In this talk, we will introduce what we have done for innovative teaching of Linear Algebra and Calculus with Sage. (Received September 26, 2012)

- 1086-G5-1260 **C Ray Rosentrater*** (rosentr@westmont.edu), Westmont College, 955 La Paz Rd., Santa Barbara, CA 93108. *A Geometry-first Introduction to Determinants*.

This presentation explores the benefits of a geometry-first introduction to determinants. When the usual algebraic definition of the determinant is preceded by a geometric introduction using elementary row operations, it is easier to motivate both the algebraic definition and the related theorems. Students better understand the theory through the geometry. (Received September 20, 2012)

- 1086-G5-1323 **Greg Mayer*** (greg.mayer@ceismc.gatech.edu), Georgia Institute of Technology, CEISMC, 760 Spring Street, Suite 217, Atlanta, GA 30308. *Experimenting with Graded Group Work in Online Synchronous Math Recitations*. Preliminary report.

In an effort to increase student engagement, group work activities are presently being explored in a small section of an online undergraduate level course that covers linear algebra and calculus concepts. The 16 high achieving high school students enrolled in this section, all of whom have completed AP Calculus, were loaned graphics tablets for the semester so that graded group work activities could be facilitated in their recitations, which are held twice per week. Recitations were offered through web conferencing software that enabled students to communicate with text chat, voice, and a shared whiteboard. Analysis of student grades and feedback collected through two online surveys will be presented to describe 1) ways to refine the recitation activities to better promote student learning, 2) whether recitation activities for students are successful in adequately preparing students for course assessments (assignments, quizzes, and final exam), 3) ways recitation activities can be designed based on students’ learning goals, and 4) whether the collaborative learning activities lead to an increased level of interest in recitations among high school students. (Received September 21, 2012)

- 1086-G5-1376 **Susan Eileen D’Agostino*** (s.dagostino@snhu.edu), SNHU Mathematics Department, 2500 North River Road, Manchester, NH 03104. *A Linear Algebraic Approach to An Old Calculus Standby*.

Most math majors are capable of rattling off an impressive list of linear algebra applications in areas outside of mathematics, including computer graphics, GPS technology, economic modeling and robotics. But do they know of an application of linear algebra in a subject that is closer to “home?” Though most students pursue calculus

before linear algebra, few see a connection between these two mathematical fields. In this talk, we present a linear algebraic approach to that old standby of a first-semester calculus course: differentiation. In doing so, linear algebra students may begin to grasp, in the words of Johann Wolfgang von Goethe, that “everything is simpler than you think and at the same time more complex than you imagine.” (Received September 21, 2012)

1086-G5-1677 **Joshua J Thompson*** (joshthom@nmu.edu). *From Videos to Vectors: What if $Ax=b$ meant $Ax=Me$?* Preliminary report.

We all know that students learn best when they are interested in and interact with the mathematics in front of them. Motivated by this we explore the successes and pitfalls of teaching a Linear Algebra course from the point of view that vectors are digital images, quite possibly one's own.

Given that a typical digital image is stored as a three-dimensional matrix of pixel values, we reshape a set of images into a set of vectors in R^n where n is quite large. Reframing vectors as images breathes new life into established notions of distance, norm and subspace. The class then computes which two students are most similar (or dissimilar) in appearance. Students literally see the effect of projecting one's own vector onto their classmates' subspace. Eigenfaces are computed which not only pique interest by their ghostly nature, but also reflect an active area of research in the image processing community. Interacting with the mathematics this way entices students to dive deeper into the theory because it is their own images in their hands. (Received September 24, 2012)

1086-G5-1698 **Karsten K. Schmidt*** (kschmidt@fh-sm.de). *Teaching Matrix Algebra with Magic Squares.*

A magic square of order n is a square arrangement of nn real numbers, such that the sums of the elements in each row, column, and diagonal are equal to a constant s , its magic sum. If an nxn matrix M denotes a magic square, and j denotes an $nx1$ vector of ones, the following activities can be carried out in class (if possible, using technology to simplify calculations): computing the matrix product Mj and comparing it to the scalar product sj to check whether the n row sums are indeed equal to s ; computing the trace of M to check whether the sum of the elements of the main diagonal is equal to s ; reconsidering the equation $Mj = sj$ to discover that s is one of the eigenvalues, and j an associated eigenvector, of M . Any $3x3$ magic square can be written as the sum of two matrices, $M = sG + N$, where $G = 1/3J$ ($J=jj'$ denotes the $3x3$ matrix of ones), and also N has a simple structure defined by only two real numbers. The matrices G , N , and M provide good examples to compute the trace, determinant, rank, and eigenvalues, and investigate the connections between them. A further interesting activity is to compute the (Moore-Penrose) inverse of M , and investigate whether it is also magic. The Lo-Shu magic square (4,9,2;3,5,7;8,1,6) will be the example used in the presentation. (Received September 24, 2012)

1086-G5-1858 **Annala R Kelly*** (a3kelly@bridgew.edu). *Projects in Linear Algebra.* Preliminary report.

My talk will describe how the theory and applications of linear algebra merge together for my students. The students work in groups of two to study problems from business, biology, physics, engineering, mathematics or other fields that can be solved using linear algebra tools. The students use Maple for their calculations and organize their results on a poster. The culmination is a presentation to classmates during the class and a poster presentation at the campuswide Mid-Year Symposium for Freshmen and Sophomores. (Received September 24, 2012)

1086-G5-1912 **Heidi Hulsizer*** (hhulsizer@hsc.edu), P.O. Box 142, Hampden-Sydney, VA 23943. *Algebra in Call of Duty: Black Ops?*

The video game Call of Duty: Black Ops is popular to an audience of college students and surprisingly we can use algebra to solve a problem that appears in the game. The problem involves turning dials to reach a solution, but turning one dial also turns others. Two perspectives on the solution will be presented; one involves solving a system of equations modulo ten and the other involves converting a directed graph with four vertices into a matrix equation. This example provides an affirmative answer to the question, will I ever use math in real life? (Received September 24, 2012)

1086-G5-2168 **A Bathi Kasturiarachi*** (akasturi@kent.edu), Department of Mathematics, Kent State University at Stark, North Canton, OH 44720. *Creating a Blended Linear Algebra Course.*

A blended course has fewer class meetings and is augmented with online learning. Such courses are attractive from both learning and administrative standpoints. In the presentation, we will outline our re-design of Linear Algebra. Blended courses take into consideration students' needs, learning styles, and schedules and incorporate administrative concerns such as classroom space and technology, to design an optimal learning environment.

Each course has e-notes available on the web with selected topics on podcasts. These notes have a variety of interesting examples of moderate difficulty. Lab modules are designed using Maple. We will explain the advantages of blended courses and share preliminary results from such course offerings. (Received September 24, 2012)

1086-G5-2303 **Jon Davidson*** (math@sscc.edu), Southern State Community College, Hillsboro, OH 45133. *Hidden treasures in 2×2 linear systems—applications of non-orthonormal coordinate systems.*

A consistent $n \times n$ linear set of equations sets up a coordinate system which may not be orthonormal. This talk focuses on several applications of such derived vector spaces in R^2 : density of lattice points in the plane intersected by the new axes, transformations of functions, calculus in a non-orthonormal vector space, including double integration using Jacobians, and applications of eigenvectors. Thus we can take a mundane 2×2 set of linear equations and find rich, visual applications to linear algebra and other branches of math. (Received September 25, 2012)

1086-G5-2308 **Robert C Ray*** (rayr@gonzaga.edu), Gonzaga University, MSC 2615, 502 E. Boone Ave., Spokane, WA 99258. *G-Sets and Linear Recurrences Modulo Primes.* Preliminary report.

We consider second order linear recurrence relations of the form $S_n = aS_{n-1} + bS_{n-2}$ over the finite field Z_p , where p is a prime not equal to 2. Although the results regarding the distribution of elements in the sequence $\{S_0, S_1, \dots\}$ are well known, we recover these results using matrix groups, linear algebra and G -sets as related to the eigenspaces in the finite vector space $Z_p \oplus Z_p$. It is our hope that this alternate view may provide a set of material or examples that could be utilized in undergraduate mathematics courses. (Received September 25, 2012)

1086-G5-2355 **Scott F Beaver*** (beavers@wou.edu), Mathematics Department, Western Oregon University, 345 N. Monmouth Ave., Monmouth, OR 97361. *The Flip Side of Linear Algebra.*

I present an Introduction to Linear Algebra course I offered during Fall term 2012. Using an Echo Smartpen, I posted relatively short pencasts on the course page, and had students work in groups of three on the homework problems during class time. The groups were instructor-selected and changed twice during the term. Various protocols were put in place to ensure that students stayed on-topic. I'll discuss survey results and a comparison of grades from Fall 2012 and the previous two Introduction to Linear Algebra courses I have taught. (Received September 25, 2012)

1086-G5-2535 **Minah Oh***, Department of Mathematics and Statistics, 315 Roop Hall, MSC 1911, James Madison University, Harrisonburg, VA 22807. *An Applied Project for Linear Algebra Students: Finite Element Methods.*

In this talk, I will talk about an applied project for linear algebra students. Finite Element Method (FEM) is a very well-known efficient method one can use to find a good approximation for the exact solution to a given PDE. Not only is its applications in science and engineering tremendous, it is also an excellent application of linear algebra. In this project, students were introduced to the FEM through a very simple differential equation problem. Through this simple example, the students learn the essential idea of the FEM by using linear algebra. Furthermore, they learn the real world applications of FEM so that they can see linear algebra in action in the real world. (Received September 25, 2012)

1086-G5-2569 **Brandy A. Benedict*** (brandy.benedict@merrimack.edu), Department of Mathematics - N5, Merrimack College, 315 Turnpike Street, North Andover, MA 01845. *Active Learning in the Linear Algebra Classroom Using Sage.*

As a free, open-source alternative to proprietary software, Sage provides a powerful and easily accessible way to perform numeric and symbolic calculations and generate 2- and 3-d plots. In this talk I will discuss how I use Sage to illustrate linear algebra concepts in an active learning environment. During lab periods, students use Sage as a tool to investigate properties of systems of equations, vectors and matrices, determinants, vector spaces, linear transformations, and eigenvalues and eigenvectors. Student feedback to this method of instruction will be presented, as well as lessons learned. (Received September 25, 2012)

1086-G5-2872 **Shannon R Lockard*** (slockard@bridgew.edu). *Mapping Out the Invertible Matrix Theorem.*

Students often find the topics in an introductory linear algebra course to be disconnected and isolated. One of the most unifying theorems that students learn in linear algebra is the Invertible Matrix Theorem. However,

students often fail to recognize the importance of this theorem that brings so many topics of the course together. Consequently, they fail to connect the topics of the theorem. In this talk, I will describe a discovery activity in which I have my students work out a map of the proof of the Invertible Matrix Theorem. The activity typically has three parts: an in-class group portion, a class discussion held the next class period that begins with the results of the group work, and an out-of-class assignment to wrap up the discussion. During the course of the activity, the students review important concepts, grapple with precise statements of definitions and theorems, clarify the results and consequences of these definitions and theorems, and finally make the connections between the topics given in the Invertible Matrix Theorem. (Received September 25, 2012)

1086-G5-2928 **Randall Pruim*** (rpruim@calvin.edu). *How a little linear algebra can go a long way in the Math Stat course.*

Statistics courses generally take an approach that avoids linear algebra altogether or assumes more linear algebra than most undergraduates have seen when they take their first statistics course. This talk explores a middle ground where a brief introduction to or review of linear algebra that emphasizes a geometric approach is used to demystify things like degrees of freedom and linear models. Treating data as a vector (or matrix) also mirrors how it is treated in modern computational tools like R, which is used for numerical applications. (Received September 26, 2012)

Innovative Ideas for Courses in the First Two Years

1086-H1-76 **Scott A Stevens*** (stevens@champlain.edu), Burlington, VT 05401. *An Innovative Course for Teaching Topics from Calculus III and Linear Algebra for Computer Science-Related Majors Utilizing Game-Programming Applications.* Preliminary report.

Providing a proper balance of industry-specific curriculum, general education, and a complete math sequence is difficult for colleges offering computer science-related degrees. This session will describe an innovative math course developed at Champlain College which helps our undergraduate computer science-related majors learn the most relevant math in the fewest number of credits. What started out as a math course for game-programmers quickly, and quite naturally, became a sequence of game programming objectives motivating the math topics I wanted to cover in a limited number of credit hours following a single Calculus course. After having taught this course many times I now believe that more math courses and topics should be motivated by such objectives. Due to the success of this course, and a simultaneous increase in retention, it is now part of the required math sequence for all of our computer science related majors. In this session I will present the details of our course called *Matrices, Vectors, and 3D Math: A Game Programming Approach*. I will demonstrate how a sequence of easy-to-code games can motivate much of the relevant material learned in Calculus III and Linear Algebra. A collection of student assignments and projects will be demonstrated using MATLAB. (Received July 06, 2012)

1086-H1-143 **Jeffrey W. Clark*** (clarkj@elon.edu). *Stressing Physics Content in a Multivariable Calculus Class.*

The CUPM has repeatedly stressed the need to encourage bridges between mathematics and related disciplines, particularly in courses that serve those disciplines. Multivariable calculus is an excellent course to demonstrate how the tools of calculus are used in physics. This course will discuss examples of such content as well as how current technology facilitates their coverage, encouraging students to continue their studies in both disciplines. (Received July 27, 2012)

1086-H1-160 **Rachel Frankel*** (frankere@ucmail.uc.edu), University of Cincinnati, Blue Ash College, 9555 Plainfield Road, Blue Ash, OH 45236. *Improving Student Learning Using Interactive Lecture Notes.*

Note taking in mathematics seems straightforward; students need only copy equations from the board. Students in the first two years of college invariably copy inaccurately, write illegibly, lose their notes, and are so focused on writing that they don't think. Distributed notes which outline the lecture, section, or topic facilitate student understanding and organization in the crucial introductory mathematics courses of the first two years. These notes start with the title of the topic or section followed by bullet pointed goals. Each subtopic is clearly labeled and contains relevant definitions, formulae, diagrams, and figures. Exercises that will be demonstrated in class or will be worked on in groups are written with adequate space left for the students to fill in. These notes can also be posted online for easy student access. Advantages of distributed outlines include aiding student organization, adding structure to lectures, defining outcomes, and allowing stronger students to work ahead. They promote accuracy and completeness. Students can take a step back and understand and analyze rather than just trying

to keep up. Student feedback has been extremely positive. Student participation in class and student motivation to solve additional problems has markedly increased. (Received July 31, 2012)

1086-H1-320 **Mike May*** (maymk@slu.edu). *Rethinking Business Calculus with Spreadsheets and Laptops*. Preliminary report.

The chapter on Business and Finance in the 2004 Crafty report on the Voices of Partner Disciplines had a number of recommendations, including more extensive use of spreadsheets and modeling. It also suggested mathematics faculty should engage in discussions with the business faculty to see what they wanted out of the mathematics courses for their students. We have attempted to do this in the one semester calculus course aimed at business students. Rather than attempting this as an add on to a text that is technology neutral, we wrote an electronic text that assumes the students will have a computer with a spreadsheet and the internet available for their classes. It is now reasonable to assume that students will bring their own computers. Given the realities of service courses, the goal of the project includes developing materials that can be used by adjuncts or teaching assistants. We will look at features of the text and reactions from students and faculty in both business and mathematics. (Received August 20, 2012)

1086-H1-406 **Regina D. Aragon*** (regina.aragon@enmu.edu), ENMU, Station 18, Portales, NM 88130, **Tom Brown** (tom.brown@enmu.edu), ENMU, Station 18, Portales, NM 88130, and **Matt Bell** (matt.bell@enmu.edu), ENMU, Station 18, Portales, NM 88130. *Flipping A College Algebra Classroom*. Preliminary report.

In an effort to improve student success in College Algebra, the presenters are transforming sections of College Algebra from a primarily lecture based format to a flipped classroom. The desired effects of this initiative are to improve students' performance and appreciation of mathematics by increasing student engagement, and making the material more accessible to students.

The design of this flipped course includes pre-class videos to be viewed by students along with on-line homework of easier computational-type problems, and in-class activities/exercises with an emphasis on applications. This presentation will include the theory behind a flipped classroom, details of the course design and materials, outcomes, and future plans. (Received August 29, 2012)

1086-H1-549 **David A. Brown*** (dabrown@ithaca.edu), Ithaca College, Department of Mathematics, 953 Danby Road, Ithaca, NY 14850. *Experimental Mathematics for the First Year Student*.

As an alternative to the traditional Calculus sequence, the Ithaca College Mathematics Department has been offering an introductory course in experimental mathematics. The course uses computer experimentation in an inquiry-based learning environment to teach students how to generate mathematical conjectures and then support and/or prove those conjectures with reasoning. Students from a wide variety of majors have completed the course and gone on to take further courses to complete a minor in mathematics. The course is also required for the mathematics major. In the six years that the course has been running, we have doubled enrollment and seen an improvement in student writing and communication. These improved abilities have transferred to later mathematics courses, most notably the department's junior level research course sequence.

In this talk, we will present an overview of the course, including its philosophy of experimentation. We will discuss the weekly open-ended "labs" completed by the students and how they are required to write mathematical reports summarizing their experimental results and their associated reasoning. We will provide examples to demonstrate student growth in mathematical understanding and reasoning. (Received September 06, 2012)

1086-H1-711 **Cynthia Y. Young*** (cynthia.young@ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *i-IBL Interactive Inquiry Based Learning: Improving Student Conceptual Learning in Precalculus*.

Interactive figures provide an opportunity to explore a mathematical concept. Inquiry Based Learning puts the control of learning in the hands of the student in a discovery mode. Integrated together, these two pedagogies have the potential to increase student conceptual learning. An example of an i-IBL (Interactive Inquiry Based Learning) on power functions (discovering the characteristics of even and odd functions) will be demonstrated from the perspective of a student in an online environment. (Received September 11, 2012)

1086-H1-973 **Feryal Alayont*** (alayontf@gvsu.edu), GVSU Mathematics Department, 1 Campus Drive, Allendale, MI 49401, and **Derek Habermas** (habermas@potdams.edu), Department of Mathematics, SUNY Potsdam, 44 Pierrepont Ave, Potsdam, NY 13676. *Preparing Students to Make Mathematical Connections for Better Success*. Preliminary report.

When students arrive in the classroom, we wish them to be well-prepared for the learning to happen. However, especially in the first two years in college, many students may need guidance in this preparation. In this talk,

we will describe our use of pre-class activities in calculus and linear algebra classes to help students be ready for learning, more specifically ready for learning with understanding. Sample activities and student reactions to the use of these activities will be included. (Received September 17, 2012)

1086-H1-1029 **Joseph Petrillo*** (petrillo@alfred.edu), Division of Mathematics, 1 Saxon Drive, Alfred, NY 14802. *The Alfred University Calculus Initiative.*

The Alfred University Calculus Initiative (AUCI) is a multi-faceted project that combines a new and distinctive curriculum with classroom transformation, video lessons, online homework, and web-based implementation into a comprehensive calculus experience. The goal of the AUCI is to increase understanding and success in calculus and precalculus while maintaining the level of rigor and breadth required for post-calculus courses. This project is being informed by current research and trends in STEM education, which include engaging students with visual and online technology, creating an active learning environment in the classroom, and incorporating meaningful applications. In this talk, we will discuss the motivation and content of the new curriculum and give convincing data that supports its effectiveness. This project is partially supported by the National Science Foundation (DUE-1140437). (Received September 18, 2012)

1086-H1-1049 **Jeff Suzuki*** (jeff_suzuki@yahoo.com), Brooklyn College, Department of Mathematics, 2900 Bedford Ave., Brooklyn, NY 11210. *Mathematics and the Law: Recruiting from the Social Sciences.*

More than a century ago, Oliver Wendell Holmes Jr. noted that, with regard to the legal profession, “the man of the future is the man of statistics and the master of economics.” We have developed a course (based in part on material field-tested in other courses) that brings together mathematics and legal issues, including discrimination in jury selection and employment contexts; fairness issues in the design of congressional districts; and determining whether a recount is warranted in an election with disputed ballots. (Received September 18, 2012)

1086-H1-1247 **Lee J Fothergill** (lee.fothergill@msmc.edu), 330 Powell Ave, Newburgh, NY 12550, and **Mike Daven*** (mike.daven@msmc.edu), 330 Powell Ave, Newburgh, NY 12. *Math Trails Across Your Campus.*

Students often learn best when they are actively engaged in the learning process. A Math Trail is an activity where participants encounter examples of mathematics in their surroundings and an excellent way to make connections to your campus and local and regional history. Students at all levels can learn from math trail activities that have already been prepared, and can learn even more by developing math trail activities of their own. We will describe how for the last four years freshman and sophomore mathematics majors at Mount Saint Mary College have created their own math trail activities, increasing their own understanding and inspiring others to consider a degree in mathematics. We will also talk about how similar activities can be implemented on your campus. (Received September 20, 2012)

1086-H1-1354 **Larissa B Schroeder*** (schroeder@hartford.edu), University of Hartford, Department of Mathematics, 200 Bloomfield Ave., West Hartford, CT 06117, and **Mako Haruta, Jean McGivney-Burelle, Fei Xue and John Williams.** *Flipping Calculus.*

In this session we will present the results of a recent project to implement a “flipping” pedagogy in some sections of Calculus I at the University of Hartford. In the flipped sections presentation of content was moved outside of class, via online videos produced by the department, while problem solving and applications, was shifted into the classroom. Class time consisted of quick check quizzes, short mini-lectures, small group problem solving and whole group discussions. The other sections of Calculus were largely taught via lecture. We will discuss the technology and logistics involved in this project as well as the benefits and challenge of this pedagogy. Preliminary data from pre/post tests and student and instructor surveys will be shared. (Received September 21, 2012)

1086-H1-1439 **Paul E Seeburger*** (pseeburger@monroecc.edu), Monroe Community College, 1000 E. Henrietta Rd., Rochester, NY 14623. *Visually Verifying Homework Problems in Multivariable Calculus.*

Multivariable Calculus involves many concepts that require three-dimensional visualization to fully understand. Using CalcPlot3D, an online applet, students can view & print visual verifications for a variety of multivariable calculus homework problems. Examples include the plane determined by three points, the intersection of two surfaces, contour plots, directional derivatives, tangent planes, level surfaces, Lagrange multiplier optimization, and Riemann sums of rectangular prisms. Short video lessons using CalcPlot3D to visually verify examples of many of these topics can be found on YouTube, and four assessment/exploration activities have been created to

help students "play" with the 3D concepts themselves, and to assess improvements in geometric understanding gained from these activities. CalcPlot3D is part of an NSF-funded grant project called Dynamic Visualization Tools for Multivariable Calculus (DUE- CCLI #0736968). See <http://web.monroecc.edu/calcNSF/>. (Received September 22, 2012)

1086-H1-1728 **Maria Terrell*** (mst1@cornell.edu), Mathematics Department, Malott Hall, Cornell University, Ithaca, NY 14853, and **Peter Lax** (lax@cims.nyu.edu). *Single Variable Calculus Revisited*.

As mathematicians and educators our goal must be to simplify the teaching of old topics, and make room for new ones. It is fair to ask: Why should we introduce any new subject material, or new ideas into calculus? Here is the paradox of education: Science and mathematics are growing by leaps and bounds on the research frontier, so what we teach in high school, college, and graduate school is falling behind by leaps and bounds. This paper reports on Maria Terrell's and Peter Lax's efforts to revise the 1977 text "Calculus with Applications and Computing" by Lax, Burstein and Lax. The original text was predicated on a number of fairly unconventional ideas and it included some very new and non traditional material. We share our current efforts to introduce new subjects in the basic calculus course. (Received September 24, 2012)

1086-H1-1738 **Andrew Bucki*** (ajbucki@langston.edu) and **Abebaw Tadesse**. *New Educational Program in Mathematics for STEM Majors, Part I*. Preliminary report.

For the last several years we have worked on developing the New Educational Program in Mathematics for STEM Majors. The program employs an innovative and transformative 'more learning = less teaching, with partnership and programming' approach to the existing system. The present educational system is based on teacher dominated relationship that is characterized by: slang mathematics, examples are almost always given by teachers, students copy or imitate to memorize, only some critical thinking, fear of mathematics, and less creativity. Our model, on the other hand, primarily addresses the more fundamental issue of motivating and preparing unmotivated and underprepared students. The fundamental difference between the existing program and our program is that our program makes students think constantly as if they were talking to a computer instead of routinely reproducing sample examples. Then it is natural to think that they should create programs to communicate with a 'virtual computer'. They translate a definition, property, or formula into a 'computer program' to 'run' it to master the underlying mathematical concept instead of routinely repeating existing algorithms provided by a teacher. In this presentation we will briefly illustrate the main ideas of the program. (Received September 24, 2012)

1086-H1-1890 **Itai Seggev*** (is+research@cs.hmc.edu), 100 Trade Center Dr, Suite 600, Champaign, IL 61820. *Changing Perspectives on Changing Coordinates*.

When teaching vector calculus, coordinate transformations are usually treated in somewhat haphazard way. Typically, we introduce the change of variables theorem for integration, and we hurry along before our students ask too many questions. This is understandable, since treating coordinate transformations in generality can quickly lead to differential geometry that our students are ill-prepared to learn.

In this talk we will argue that by using a CAS to perform the actual transformations, we can allow our students to explore different coordinate systems and the transformations between them in a deeper way. At the same time, we can drive home important topics such as unit basis vectors, orthogonal projection, and orientation. (Received September 24, 2012)

1086-H1-1980 **Debra Hydorn*** (dhydorn@umw.edu), University of MaryWashington, 1301 College Avenue, Fredericksburg, VA 22401. *Exploratory Projects in an Introduction to Discrete Mathematics Course*.

As part of the University of Mary Washington Mathematics Department outcomes assessment program we have identified a series of student outcomes for our courses. These include correct use of mathematical notation, analyzing and constructing logical arguments and formulating conjectures from exploration and experimentation. Of these outcomes, our Introduction to Discrete Mathematics course did not include content or activities to promote exploration and experimentation. Because this course is a prerequisite to upper level courses in the major I have written a series of ten exploratory projects, some of which are extensions of topics covered in class while others cover new topics but require students to apply course topics in a new way. Some of these projects are adaptations of projects in the MAA publication "Resources for Teaching Discrete Mathematics: Classroom Projects, History Modules and Articles" while others came about from discussions with colleagues. Preliminary results indicate that a majority of students report improvement in our department outcomes upon completion of the course. (Received September 24, 2012)

- 1086-H1-2027 **Edmund A. Lamagna*** (eal@cs.uri.edu), Dept of Computer Science and Statistics, University of Rhode Island, Kingston, RI 02881. *Mathematical Problem-Solving and Algorithmic Thinking.*

Puzzles and games form the basis of a freshman seminar designed to develop mathematical and computational problem-solving skills. The desired learning outcomes include: 1) helping STEM students transition from high school to college, 2) motivating and creating excitement for the further study of mathematics, computer science, and other STEM subjects, 3) allowing STEM students to work in small groups on fun, interesting problems, 4) introducing mathematical and computational problem-solving strategies not typically encountered in high school or college, 5) instilling the confidence and persistence needed to solve complex, difficult problems, 6) encouraging “out of the box” thinking and applying alternative problem-solving strategies, and 7) exposing students to real-world applications.

Each session begins by introducing a set of puzzles of a particular type or a game illustrating a particular principle. Students spend most of the period in small groups solving puzzles or playing the game. Toward the end of class, students discuss general solution techniques with guidance from the instructor. While the presenter is teaching this course for the first time with freshman, he has successfully incorporated a similar approach into an intermediate course in discrete mathematics. (Received September 25, 2012)

- 1086-H1-2114 **Marilyn A. Reba*** (mreba@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29631, and **Taufiqar Khan, Ellen Breazel, John DesJardin** and **Irina Viktorova.** *Emphasizing Core Calculus Concepts Using Biomedical Applications to Engage, Mentor and Retain STEM Students.*

With support from Hewlett-Packard Awards and a 4-year NSF-CCLI Grant, the Department of Mathematical Sciences at Clemson partnered with Computer Science to develop and implement technology (web-based software, digital ink) in Engineering Calculus I. The goal was to personalize instruction in large active-learning classrooms. Our current focus, via an NSF-TUES grant, is to motivate interest in calculus by immersing students in bioengineering and biomedical applications, and then converting ideas from these experiences, again with the help of Computer Science, into interactive “mobile apps” for both Ipad and Android tablets. Beginning in Fall 2011 and continuing through 2013, students with STEM majors have the opportunity to enroll in four (1 credit hour) creative inquiry modules, taken in parallel with the freshman and sophomore calculus curriculum, on epidemiology, orthopedics, heat propagation in the human body, or radiology. We will present descriptions of module content, and initial findings about 1) students’ changing perceptions of math, 2) successful performance in calculus courses; and 3) retention as STEM majors. Also, we will demonstrate one of our newly-developed mobile apps. (Received September 24, 2012)

- 1086-H1-2217 **Poul G. Hjorth*** (p.g.hjorth@mat.dtu.dk), Department of Mathematics, Technical University of Denmark, Matematiktorvet 303-B, DK-2800 Kgs. Lyngby, Denmark, and **Steen Markvorsen** and **Karsten Schmidt.** *Back to the Future.*

The mandatory first-year mathematics course at the Technical University of Denmark serves roughly 10^3 students. The course has been developed as a one-year course, in with vector analysis and linear algebra are developed in parallel. The students use Maple extensively. We report here on the evolution of this curriculum, the challenges, the current practice, and a recent modification, banning all forms of electronic aids for the first four weeks of the course. (Received September 25, 2012)

- 1086-H1-2357 **Eve Torrence***, etorrenc@rmc.edu. *An Online Discussion Forum for Calculus Students.*

Last spring I set up an experimental online homework discussion for my Calculus 1 students. I used the Forum option in the open source course management system Moodle. It was a wonderful success. I’ve made adjustments to improve the quality of the student participation and it is even more effective this semester. Students are extremely good at explaining solutions to each other. They are willing to write out detailed questions and answers. Now I spend far less time going over homework in class. And I am able to see which problems are truly difficult for my students as opposed to those they got wrong because they made simple mistakes. I use online homework and this discussion is a natural extension of the online system.

The preparedness of our Calculus 1 students varies greatly. While this can be a real challenge, having students who bring different skills to the course can be a big advantage in an online discussion. Students benefit from the discipline of typing out both questions and answers. Having a permanent record of questions and answers that can be referenced later in the semester is also useful.

I will discuss my experiences and improvements to the Forum and show examples of my students’ discussions. (Received September 25, 2012)

- 1086-H1-2379 **Edwin P Herman*** (eherman@uwsp.edu), Department of Mathematics, University of Wisconsin-Stevens Point, Stevens Point, WI 54481. *Are Numbers Real? – a First Year Seminar*. Preliminary report.

As part of a recent initiative at the University of Wisconsin-Stevens Point, I created and taught a Freshman Seminar in Fall 2012. Instructors were expected to blend various "introduction to college" outcomes with topics that excited the instructor. I decided to explore numbers and number systems - I wanted students to question the form, meaning, and operations of the numbers they simply take for granted. My first cohort was about 50% declared STEM majors and 40% undeclared.

The course started by exploring cultural and historical views about numbers, looking at notation and counting but also thinking about how language shapes perception of numbers. After touching on Ethnomathematics, the course shifted to analysis of particular number systems, such as Gaussian Integers and cyclic groups, investigating how they differed from ordinary integers. The course finished with a brief development of p-adic numbers. Along the way, we dealt with more mundane concepts such as choosing a major and finding valid sources for a paper.

In my presentation I will discuss the topics covered and what worked (or didn't); student feedback on the course will also be given, and an attempt will be made to gauge the impact (if any) this course has on students' interest in the mathematical sciences. (Received September 25, 2012)

- 1086-H1-2406 **Charles Bergeron*** (chbergeron@gmail.com), **Lisa Morkowchuk** and **David Clarke**. *Strengthening data analysis knowledge and skills through practice*. Preliminary report.

We teach 'Introduction to Laboratory Data' to our first-semester Bachelor of Science students. We aim to reinforce fundamental mathematical and statistical concepts by giving students the opportunity to practice them in a scientific setting. The course cornerstone is weekly laboratory activities that engage students in making measurements and thinking critically about experimental data. Examples include estimating the volume of air in a classroom, describing the distribution of the mass of ibuprofen capsules, propagating measurement error in estimating the density of a penny, assessing variations in body temperature, regressing speed from times and positions, and analyzing the Michaelis-Menten enzyme kinetics equation. We also focus on using spreadsheet software to organize and present data using appropriate tables and graphs. Through these labs, students learn about significant figures, scales of data, exponential models and logarithmic manipulations. This course prepares students for all laboratory courses in their curriculum and provides a gentle transition leading to statistics and calculus. In this talk, we discuss this course's motivation and structure, and present several lab activities that engage students in harnessing mathematics and statistics when doing science. (Received September 25, 2012)

- 1086-H1-2686 **Michael S Gagliardo*** (mgagliar@callutheran.edu). *Combining Khan Academy and Active Learning in Pre-calculus*.

Students enter pre-calculus with a diverse mathematical background. Presenting the material at the appropriate level for all students in the course becomes exceptionally challenging. In order to address individual students' needs, I used both the Khan Academy and an active learning approach in my pre-calculus courses. In this talk I will discuss the rationale behind this method, the structure of the course and student reactions. (Received September 25, 2012)

- 1086-H1-2860 **Sheila K Miller*** (smiller@citytech.cuny.edu). *Inspiring Mathematical Interest through Interdisciplinary Projects*.

The ability to pose questions and to approach those questions mathematically is one of the core skills of a mathematician, thus fostering this skill is one of the primary roles of a teacher of mathematics. We take the position that it is often easier to teach students the competencies and joys of asking and exploring questions using an interdisciplinary approach rather than an exclusively mathematical one; attempting to inspire wonder and awe at any aspect of mathematics can be difficult in before-calculus level classes, but in our experience the ubiquitousness of mathematics as the subtle language of the universe is a good place to start — and one with many questions that are genuine and uncontrived. Some degree of mathematical curiosity is required to find mathematics interesting, and seeing that mathematics can be interesting is for many students a prerequisite for wanting to do more of it. We describe a multidisciplinary before-calculus level semester project that strives to generate curiosity about mathematics through investigation of pulsars, and report student reactions to that project. This project includes: chemistry, biology, astrophysics, supernovae, Little Green Men, Tycho Brahe, and Shakespeare's Hamlet. (Received September 25, 2012)

- 1086-H1-2896 **Sarah E. Eichhorn*** (sfrey@math.uci.edu), 340 Rowland Hall, Department of Mathematics, University of California, Irvine, Irvine, CA 92697, and **Rachel Lehman**. *An Online Pre-Calculus Course using ALEKS.*

UC Irvine recently undertook the creation of an efficient, scalable, portable and rigorous pre-calculus course. The course utilizes ALEKS software to allow each student an asynchronous learning experience focused on working on exactly the topics they have not yet mastered and are ready to learn. For this course we have created over 150 short video lecturettes which are now openly available online.

In this talk, we will discuss data on student performance in traditional vs. online implementations of this course. We will also share some of the challenges associated with online instructor-student and student-student mathematics discussions and our implementations. (Received September 26, 2012)

- 1086-H1-2931 **Christopher Schroeder*** (c.schroeder@moreheadstate.edu). *Signing on to Redesign.*

Recently Morehead State University's College Algebra class has undergone a drastic redesign. Through a grant from the National Center for Academic Transformation (NCAT) we have modified our delivery of content, lecture time, student requirements and amount of student interaction. We will look at the details of how the course was redesigned, technology used, implementation issues and solutions, possible additional changes for the future, and early results showing the effectiveness of the changes. (Received September 26, 2012)

Integrating the Mathematics of Planet Earth 2013 in the College Mathematics Curriculum

- 1086-H5-104 **James A. Walsh*** (jawalsh@oberlin.edu). *Conceptual climate models and the undergraduate curriculum.*

Were glaciers discharging into the ocean in the tropics at one time? Or was the Earth ever completely ice-covered? Simple energy balance models of planetary climate will be presented, one of which incorporates the movement of glaciers in response to the ice-albedo feedback. Certain aspects of the models are appropriate for the first ordinary differential equations course, while other aspects would fit nicely in a mathematical modeling course having an emphasis on computation. (Received July 18, 2012)

- 1086-H5-458 **Dan Seth*** (dseth@wtamu.edu), Department of Math, Chemistry and Physics, WTAMU Box 60787, Canyon, TX 79016. *Modeling TOMS (NASA) data to predict the depletion of the ozone layer for various latitudes of the earth.* Preliminary report.

Student groups in a class are assigned different latitude bands for which to collect monthly ozone data for their latitude. Data for each year that ozone data is accessible at the TOMS site is used to model annual average ozone thickness. Groups determine linear regression models to predict future ozone levels and to assess ozone depletion trends by latitude band. Students present their group models and assess trends by latitude band then compare other group models. Additionally, groups study an aspect of physical sciences related to ozone. In upper level classes, students collect all of their own data. In lower level classes, e.g., college algebra, students work with prepared data sets in groups by latitude band. Students find the activity very revealing. They are shocked to see that real, current data belies rather severe trends and issues for their not so distant future. Samples of student work, models, and assessment will be presented. (Received September 03, 2012)

- 1086-H5-885 **Michael Olinick*** (molinick@middlebury.edu), Department of Mathematics, 314 Warner Hall, Middlebury, VT 05753. *Some Mathematics of Nonrenewable Resources: From Arithmetic to Optimal Control Theory.*

Our current civilization is heavily dependent on nonrenewable (exhaustible) resources. We use petroleum, coal, natural gas and uranium-dependent nuclear power to create electricity, heat and cool our homes, power our vehicles and manufacture our goods. Products we use every day require minerals such as copper, gold, silver, zinc and aluminum which we use up faster than the earth can replenish them. How long will such nonrenewable resources last? Are there optimal ways to manage a dwindling supply? We will illustrate how such questions can be approached using a variety of models that can be successfully integrated into a range of courses including college algebra, calculus of one and several variables, differential equations, discrete dynamical systems, computer simulation, and optimal control theory. (Received September 14, 2012)

- 1086-H5-1117 **Katie Fowler*** (kfowler@clarkson.edu), Department of Mathematics, Clarkson University, Box 5815, Potsdam, NY 13699. *Crop Rotation Modeling to Meet A Sustainable Water Yield.*

The Pacific Coast of California, is known for berry farming, a water intensive industry. The valley's aquifer is overdrawn, causing seawater intrusion and threatening freshwater resources. We investigate ways to reduce the aquifer draw by analyzing alternative farming techniques. This is accomplished by creating a mathematical farm model and optimization strategy to design farming approaches that meet a sustainable water yield constraint. Furthermore, we consider surface water analysis as a means to supplement the aquifer for farming use. These results were produced at a focused, collaborative sustainability workshop at the American Institute of Mathematics and have been the focus of several undergraduate and graduate research projects. Moreover, the underlying modeling ideas can be used to introduce simple modeling approaches in the classroom at a variety of levels. (Received September 19, 2012)

- 1086-H5-1178 **Martin E. Walter*** (martin.walter@colorado.edu). *Earthquakes, Weatherquakes and Logicquakes in the College Mathematics Curriculum.*

We will explain how the following statement can be made more precise and proved: A modest increase in global air temperature will most likely yield an immodest increase in extreme weather events, such as tornadoes, floods, droughts and so on. This theorem can be taught in any first semester calculus course, and a version of it could be presented in a high school or liberal arts math class. We will also show how simple logical considerations can help us make certain important decisions. (Received September 19, 2012)

- 1086-H5-1393 **Michael A Brilleslyper*** (mike.brilleslyper@usafa.edu). *Seeing the World Differently: Mapping the Earth's Terrain with Elevation Angles and Why it Matters.* Preliminary report.

Much of what we have learned about the Earth in recent years has come from space. Indeed, satellites have revolutionized scientific exploration, weather prediction, and even many everyday tasks. The best such example is the Global Positioning System of satellites (GPS) that we rely on for tasks from the mundane getting directions, to highly precise scientific explorations, to countless military operations. In order for GPS to operate correctly the user must have direct line of sight to the satellites. This is no problem in places that are very flat, but it is not so in mountainous regions or in deep valleys. Yet, standard performance models for how well GPS operates assume that the Earth is smooth like a billiard ball. This talk provides an overview of how actual elevation data of the Earth's terrain was integrated into modern performance models. The work involves manipulating massive data sets, data-visualization, and the repeated use of some very elementary mathematics. Unexpectedly, the work yielded a new type of map that represents a different view of our planet in terms of elevation angles to the horizon. Many of the ideas and methods are easily incorporated into college-level mathematics courses and could make interesting projects. (Received September 21, 2012)

- 1086-H5-1927 **William C Bauldry*** (bauldrywc@appstate.edu), Dept of Math. Sciences, Appalachian State University, Boone, NC 28608. *Arctic Sea Ice Extent: A Qualitative Literacy Project and an Entry Point for Environmental Mathematics.*

We present a group project based on Arctic Sea Ice Extent data for 1979 to the present obtained from the National Snow and Ice Data Center. This project offers an easy entry for integrating environmental mathematical modeling into lower division courses in a significant way. The topical nature of Arctic Sea Ice Extent, especially given the current historically low September minimum value, ties current events, the environment, and mathematical modeling together in powerful ways. Student teams use their simple models to predict the first ice-free summer for the Arctic Ocean. Our students' project reports were also used as a quantitative literacy assessment for precalculus students and for the course; results of the project's use in class will be discussed. (Received September 24, 2012)

- 1086-H5-2178 **Andrew E. Long*** (longa@nku.edu), 495 Rossford Ave., Ft. Thomas, KY 41075. *Global Climate Destabilization: Optimal Opportunity for the Mathematics of Planet Earth.* Preliminary report.

Charles Keeling's CO₂ data is a beautiful example of a terrifying graph. It gracefully ascends, oscillating in concert with the breathing of the forests of the northern hemisphere, and on target to reach 450 ppm within the next 20 years or so. The last time the Earth was at 450 ppm, the Earth was ice-free.... Climate change data and models provide a beautiful context for many concepts in mathematics. Planetary motions were in the driver's seat for climate change (before we humans took over the controls). Conic sections, spherical geometry, Fourier analysis, parametric curves: all these find a natural niche in climate change studies. With climate change

come movements of plants and animals across the ecological landscape, as they seek to find their old niches in a new world. Dynamical systems, non-linear dynamics and feedbacks, statistical distributions, correlation and causation: so many ways to turn your favorite mathematics into an application within the context of climate change.

I will present more of my vision of how to integrate the math and science of climate change in a course being developed at Northern Kentucky University for sophomore-level STEM majors. (Received September 25, 2012)

1086-H5-2619 **Eric J Kostelich*** (kostelich@asu.edu), School of Mathematical & Statistical Sciences, Arizona State University, Tempe, AZ 85287-1804. : *Development of an undergraduate course in mathematics and climate*. Preliminary report.

This talk describes the content of an undergraduate course in mathematics and climate to be offered at Arizona State University. The target audience is second- and third-year mathematics majors (i.e., those who have completed the usual course sequence in calculus and ordinary differential equations). Topics include the basics of chaos (using Lorenz's 3-dimensional system as a model); the effects of uncertainties in data and parameters; and development of simple box models of the climate system. (Received September 25, 2012)

1086-H5-2650 **Ben Fusaro*** (fusaro@math.fsu.edu). *Environmental Mathematics via the Visual, Qualitative and Computational*.

This is a calculus-free approach to basic modeling in an environmental context. It has no prerequisites beyond HS algebra, yet students can (numerically) solve differential equations, and even pairs of such equations. This five-stage method starts with a description of the target system to a standard graph in an Energy vs Time coordinate system. In the 1st stage, the target system is represented by a simple energy diagram (a tank, or compartment). In the 2nd stage, the diagram is the basis for drawing a qualitative Energy vs Time solution graph in a standard C.S. In the 3rd stage, the diagram is coupled with a simple Input-Output (conservation of energy) argument that yields a flow equation (a DE in disguise). In the 4th stage, the flow equation is solved step-by-step via a calculator, spread sheet, or simple computer program. In the 5th stage, the computations are used to construct a standard Energy vs Time graph. The end result is five representations of the original target entity, process, or system – a diagram, a qualitative graph, a flow equation, a tabular data set, and a standard energy-time graph. (Received September 25, 2012)

1086-H5-2789 **Erin McNelis*** (emcnelis@email.wcu.edu), Dept. of Mathematics and Computer Science, Western Carolina University, Cullowhee, NC 28723. *Environmental Mathematics: The Unifying Theme in an Introduction to Scientific Computing Course*.

An Introduction to Scientific Computing course is an ideal setting for introducing students to mathematical modeling, solving complex problems, and interdisciplinary applications of mathematics. The Spring 2013 offering of this course at Western Carolina University will adopt the theme of Environmental Mathematics to help raise awareness of the role mathematics plays in understanding and potentially solving our environmental problems. This course introduces students to a variety of models (discrete, continuous, stochastic, systems-based, individual-based, statistical, etc.) and this year the examples and applied homework projects will be developed to highlight environmental mathematics applications such as predator-prey dynamics, invasive species models, mathematics in epidemiology, ecological succession models, and analysis of environmental data. As this course is required for mathematics and mathematics education majors, course discussion and projects will also address students ideas on how to better incorporate environmental mathematics in our high school and college mathematics courses. This presentation will provide an outline for course topics, examples of associated environmental mathematics applications and projects, and ideas for possible long-term course projects. (Received September 25, 2012)

1086-H5-2867 **Jessica M. Libertini*** (jlibertini@math.uri.edu), 5 Lippitt Rd., Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *Supporting and Developing a Course to Save the World*.

What does it take to develop an entire course motivated by a sustainability-related issue? We are creating a non-calculus based mathematical modeling course designed to identify policies that will allow our planet to support an ever increasing human population. In this talk, after presenting a brief overview of the course itself, we will explore the entire course development process – from finding course resources, to identifying sources of support, to the building of a day-to-day format – that allowed this idea to become an actual course offering. (Received September 25, 2012)

Learning Centers: Problems and Creative Solutions

1086-J1-806 **Gina Monks*** (monks@psu.edu), 76 University Dr., Hazleton, PA 18202. *Integration of a Math Tutoring Center with the Toys'n MORE Program.*

In this talk we describe how the integration of the mathematics tutoring center at our campus with the NSF funded Toys'n MORE program has resulted in measurable student success. Our implementation utilizes the tutoring center to facilitate gateway quizzes and retests in algebra and trigonometry courses to improve student mastery of the material. We present data showing that this student improvement has been both substantial and greater than the gains obtained from Toys'n MORE at fourteen comparable campuses that did not use our methods. (Received September 13, 2012)

1086-J1-1415 **Joseph P McCollum*** (jmccollum@siena.edu), Quantitative Business Analysis, School of Business, 515 Loudon Road, Loudonville, NY 12211, and **Yu Sun**, Loudonville, NY 12211. *Thoughts and Experiences of a Faculty Member in the Tutoring Center.* Preliminary report.

At Siena College, in upstate N.Y., the School of Business has its own Quantitative Analysis Department (QBUS). The role of this department is to teach the mathematically based courses that cover the areas of algebra, pre-calculus, calculus, and statistics and to incorporate business applications into every lecture. The faculty of the QBUS department understands the difficulties that the students may have with the courses and so they take a very active role in the tutoring center. In five of the last seven years, including the last 3 years, a faculty member has been in charge of the 8-hour a week tutoring center for the QBUS courses. There has been a lot of give and take in the tutoring room to try to make the environment as student friendly as possible. We would like to share our results and experiences in the learning center. (Received September 21, 2012)

1086-J1-1451 **Sarah L. Marsh*** (sarah.marsh@okbu.edu), **Shannon M. Griffith** (shannon.griffith@okbu.edu) and **Krista B. Hands** (krista.hands@okbu.edu). *Supporting Undergraduates' Growth as Effective Peer Tutors: What We've Tried, and What We've Learned.*

A mathematics learning center can be an invaluable part of undergraduates' experiences with mathematics, as well as an opportunity for talented undergraduates to hone teaching skills they may need in future careers. However, many of these peer tutors are asked to assist with mathematics courses that they never took as university students—if at all—creating a unique tension among the expectations of the underclassmen taking these classes, the upperclassmen tutoring these topics, and the faculty assessing students' progress. Although selecting top-notch tutors is a crucial part of a learning center's success, we also believe that training tutors to be successful—particularly in courses with which they are less familiar—plays a key role in an effective tutoring process. We will describe the steps our mathematics faculty have taken to increase tutor efficacy (and, thus, student satisfaction) in our learning center and explore both faculty and student perspectives on the impact of these actions on the quality of mathematics tutoring in our campus learning center. (Received September 22, 2012)

1086-J1-1985 **Maggie L. McHugh*** (mmchugh@uwlax.edu), 1007 Cowley Hall, 1725 State Street, La Crosse, WI 54601. *A Learning Center: Of the Students, By the Students, For the Students.* Preliminary report.

At the University of Wisconsin-La Crosse, students are at the core of our Murphy Learning Center model. Our model begins with a need for a centralized Learning Center. The students brought a proposal called Academic Initiatives to the administration and voted to increase their fees to fund, among other resources, an integrated Math, Science, and Writing Learning Center, more tutors, and a Learning Center Director. Each year, the Learning Center Director must present a new budget to a student run organization, which decides on the future budget.

The Learning Center employs students to serve as tutors and peer instructors for general education courses. The Learning Center focuses on student success, whether it be an incoming freshman student learning the differences between high school and college mathematics or a tutor preparing for graduate school gaining experience as a peer instructor.

This presentation will further explore how the Murphy Learning Center is a learning community of students, by the students, for the students. (Received September 25, 2012)

- 1086-J1-2145 **Kathy J Willis*** (k.willis@snhu.edu), 2500 North River Rd., Manchester, NH 03106. *Engaging Faculty in Your Learning Center.*

This session will focus on well tested strategies for recruiting qualified tutors and engaging faculty in supporting your Learning Center. Faculty-led walk-in tutoring and class assistants are key components in our program at Southern NH University. We have recently added a math minor/major and the challenge of providing support for many new math courses was daunting. How would we continue to provide tutoring to struggling students in general education math courses and at the same time provide support for new upper level courses? Stories of our triumphs and struggles to continue to support all students will be shared. This session is appropriate for Learning Center professionals who are interested in developing a close partnership with math faculty and math faculty who wish to bring back ideas to their learning centers for supporting all students. (Received September 24, 2012)

- 1086-J1-2602 **Mary B. O'Neill*** (moneill@hamilton.edu), 198 College Hill Road, Clinton, NY 13323. *A New Tutoring Center: Challenges, Opportunities, and Surprises.*

The Quantitative and Symbolic Reasoning (QSR) Center at Hamilton College was established in 1994 to support the QSR Requirement and quantitative and statistical courses in Biology, Chemistry, Economics, Mathematics, Philosophy (Symbolic Reasoning), Physics, and Psychology. Until this year, the Center has occupied a small classroom it could use only in afternoons and evenings.

Last year, planning began for a new, expanded facility. This paper outlines some of the stages—including discussions with students, administrative staff and physical plant and planning with architects—and the challenges of transforming a dark, enclosed, windowless, and unwelcoming space into one which is larger, brighter, and more attractive and useful to students. The transformation has brought opportunities and surprises, and has become an asset to the quantitative curriculum at Hamilton College. (Received September 25, 2012)

Mathematics Experiences in Business, Industry, and Government

- 1086-J5-80 **Dale T Smith***, Fiserv., Risk & Compliance, 107 Technology Pkwy, Norcross, GA 30092. *Bank Capital Models and Bivariate Normal Probability Calculations.* Preliminary report.

We begin our discussion of bank capital models by explaining why banks hold reserves against their assets, followed by an outline of the model used to simulate losses, the one factor capital model. The goal is to calculate expected loss, unexpected loss, and economic capital. A key calculation is the default correlation, which is an attempt to quantify whether borrowers will default together. We point out why the bivariate normal probability integral is important to default correlation and why good algorithms are important. Current work involves evaluating alternatives and extending current algorithms for bivariate normal probabilities to determine which ones are faster and preserve double precision. (Received July 09, 2012)

- 1086-J5-373 **Joy Lind***, Department of Mathematics, University of Sioux Falls, Sioux Falls, SD 57105, and **Darren Narayan**, School of Mathematical Sciences, Rochester Institute of Technology, Rochester, NY 14623. *Making Mathematics "Real" for Students.*

Traditional curricula seldom offer undergraduate students concrete examples of mathematical applications that are used in industry. As a result, many students ask themselves the question, "What else can I do with a mathematics degree besides teach?" The primary goal of the NSF-supported project STEM Real World Applications of Mathematics is to expose undergraduate students to real applications of mathematics. We are achieving this goal through the launch of a Careers in Mathematics Speaker Series that exposes students to a variety of occupations and companies that use mathematics on a daily basis, and through the development and publication of classroom modules designed to help instructors integrate problems from industry into their undergraduate curricula. In this talk, we provide highlights from the speaking events as well as details on the educational materials developed as part of this project. This initiative is supported by NSF-CCLI Grants #0536364 and #1019532. (Received August 27, 2012)

- 1086-J5-378 **Mario Livio*** (mlivio@stsci.edu). *The Greatest Scientific Achievements of The Hubble Space Telescope.*

I will review the most important scientific achievements of the Hubble Space Telescope. I will cover topics ranging from Dark Energy to Extrasolar Planets, and from the age of the universe to Supermassive Black Holes.

I will also present results of some of the most recent observations, starting with the last shuttle servicing mission to Hubble in 2009, and up to the present. Finally, along the way, I will briefly discuss open questions in astrophysics for the next decade. (Received August 27, 2012)

1086-J5-577 **James H Fife*** (jfife@ets.org), Educational Testing Service, Princeton, NJ 08541. *The automated scoring of constructed-response mathematics test questions: Why humans sometimes disagree with the computer.*

The automated scoring of constructed-response mathematics test items is a relatively mature capability that can score numeric responses and equations with 100% accuracy. But does an automated scoring engine always produce the same score that human scorers would? To find out, approximately 300 responses to each of 97 constructed-response mathematics items were double human scored and were scored by an automated scoring engine. The human and automated scores were then compared to determine how frequently and why human scores disagreed with automated scores. Of the 97 items, there were 27 items for which the human scores agreed with each other but disagreed with the automated scores. My research focused mainly on these items. How often do humans agree with each other but disagree with the automated score? Why do the humans disagree with the automated score? Based on my analysis, I developed a taxonomy of human/automated disagreement, which I will discuss in this presentation. (Received September 07, 2012)

1086-J5-580 **William P. Fox*** (wpfox@nps.edu), 2977 Sloat Road, Pebble Beach, CA 93953. *Modeling Terrorist Activities.*

We have built mathematical models to analyze terrorist and insurgent activities. We present modeling evidence as to how insurgencies or terrorist networks may grow with an example from the Philippines. We also present evidence of interdiction of terrorist activities based upon real unclassified data. (Received September 07, 2012)

1086-J5-1792 **Ashok K Deb*** (ashok.deb@usma.edu), 646 Swift Road, West Point, NY 10996, and **David Gohlich** (david.gohlich@usma.edu), 646 Swift Road, West Point, NY 10996. *Increasing efficiency is forward-picking in large-scale military warehouse.*

Given the special nature of military warehouses, standard industry practices for optimal warehouse operations do not often apply. Military warehouses can have a very unpredictable demand cycle, may be required to stop non-demanded items for long term and do not have the flexible to change operations quickly due to established regulations. The largest military warehouse is the Defense Distribution Center at Susquehanna, Pennsylvania. We apply innovative techniques to increase the efficiency of their forward-picking area. (Received September 24, 2012)

1086-J5-1946 **Bonita V Saunders*** (bonita.saunders@nist.gov), National Institute of Standards & Technology, 100 Bureau Drive, Stop 8910, Gaithersburg, MD 20899-8910. *Balancing Research Interests with Project Goals at the National Institute of Standards and Technology.*

We will discuss the recently announced NSF solicitation "Expeditions in Training, Research, and Education for Mathematics and Statistics through Quantitative Explorations of Data" (EXTREEMS-QED). EXTREEMS-QED supports efforts to educate the next generation of mathematics and statistics undergraduate students to confront new challenges in computational and data-enabled science and engineering. This presentation will inform mathematics and statistics departments interested in developing early interdisciplinary research experiences and innovative curricula in computational and data-enabled science and engineering, creating new learning environments, and sustaining the professional growth of faculty. (Received September 24, 2012)

1086-J5-2476 **Salaeha Shariff** (sshariff@aaas.org), **Eric Bone*** (fellowships@aaas.org) and **Sonja Sandberg** (fellowships@aaas.org). *Applying Mathematical Tools in Public Policy: Opportunities at the Intersection of Mathematics and Policy.*

This session explores the often overlooked yet critical role of mathematicians across government, academic, nonprofit and industry sectors to contribute leadership and innovation to effect and implement evidence-based public policy that serves society. It will delve into challenges and opportunities to bridge the gulf in culture, contexts and complexities between science and technology, policy and politics. And it will highlight experiential approaches to cultivate science and technology leaders able to apply science to public policy and support solutions to complex societal challenges (Received September 25, 2012)

- 1086-J5-2594 **Petronela Radu, Sandeep Holay and Joe Geisbauer*** (s-jgeisba1@math.unl.edu). *Math in the City: Integrating the Classroom and Applications in the Local Community.*

Math in the City is a project-based course designed to investigate real-world applications in the local community surrounding the campus. As the course focuses on local scenarios, it can easily be adopted by institutions which are surrounded by smaller communities as well. The talk will cover the design and implementation of such a course as well as viable projects for possible consideration. In particular, we wish to provide the framework for a project that focuses on a statistical analysis of the local housing market. (Received September 25, 2012)

Mathematics and the Arts: Practice, Pedagogy, and Discovery

- 1086-K1-402 **Christopher E Brown*** (cbrown@callutheran.edu). *A Model for Arranging Melodies for Ukulele.*

Like many stringed instruments, the ukulele has the property that most notes can be played in multiple ways. Given these choices, a melody might be played in a number of ways, called arrangements. We discuss an edge-weighted directed graph model for a set of arrangements and apply Dijkstra's algorithm to find an optimal arrangement of a given melody. Using this technique, we then show that the ukulele is more suitable to playing melodies in the campanella style, a baroque technique, and we show that optimal campanella arrangements derived from this model exhibit characteristics seen in expert human arrangements. Throughout, we comment on how this project was used in an introductory scientific computing and modeling course. (Received August 29, 2012)

- 1086-K1-444 **Anne M. Burns*** (aburns@liu.edu), Department of Mathematics, Long Island University, C.W. Post Campus, Brookville, NY 11548. *Gaskets and Carpets From $A(\text{Apollonius})$ to $Z(\text{The complex plane})$.* Preliminary report.

From earliest times mathematicians and artists have been fascinated with the concepts of gaskets and carpets. Starting with a compact, simply connected set in the plane, open regions are removed recursively, leaving a fractal-like limit set that contains no open sets. This talk will focus on producing mathematical art using various methods of constructing gaskets and carpets: simple recursion, circle inversions, iterated Mobius Transformations and iteration of rational functions in the complex plane. (Received September 02, 2012)

- 1086-K1-464 **Charles Redmond*** (credmond@mercyhurst.edu), Department of Mathematics/Computer Systems, Mercyhurst University, Erie, PA 16546. *Context Free Art in the Classroom.* Preliminary report.

Context Free Design Grammar (CFDG) is a programming language used for producing beautiful generative art. For the past few years, I have taught this language to first year university students, most with no computing background, as part of an interdisciplinary course in mathematics, computing, and art. No mathematics experience beyond high school algebra and geometry is required of the students. I will talk about the structure of the course and my experiences and impressions, but mostly I will exhibit the beautiful work the students have done. (Received September 03, 2012)

- 1086-K1-522 **Susan McBurney*** (smcburne@iit.edu). *DaVinci Revisited.*

This presentation continues an exploration of two pages of geometric sketches from the notebooks of Leonardo DaVinci that was presented by the author at the 2011 Joint Mathematics Meeting. DaVinci's interest in geometry was unwavering and thorough, but largely overshadowed by his accomplishments in other fields. It was even dismissed by some experts as a mere intellectual pastime. Nevertheless, careful examination shows not only the beauty of the pages, but reveals subtle geometric themes that possibly were intentional. This presentation will focus on discovering and analyzing such themes as well as exploring how they might be extended to generate new geometric artwork. It will also hopefully lead to a further appreciation of the work itself and serve to illuminate the mathematical environment in which it was created. (Received September 05, 2012)

- 1086-K1-545 **Jeff Poet*** (poet@missouriwestern.edu), CSMP, Missouri Western State University, 4525 Downs Drive, Saint Joseph, MO 64507. *A New Unit in a MWSU Liberal Arts Math Course: Math and the Fine Arts.*

I have been told for years that there is a strong connection between math and music – that these abilities often go hand-in-hand. I will share my course outline and a specific activity for a 3-week Math and the Fine Arts

unit developed for use in a liberal arts general studies course. The unit will be piloted Spring 2013. Feedback is encouraged. (Received September 06, 2012)

1086-K1-830 **Irene Iaccarino*** (irene.iaccarino@hotmail.it), via Interna Marina 19, 88900 Crotone, Italy. *Numbers in Music. Harmonies, Numbers, Notes: the Values of Pythagorean School.*

Around the 6th - 5th century, something very important happened in the history of mankind, something beautiful and enchanting. Musical harmony stirs up curiosity in a man and urges him to search parameters linked to the production of sounds and to formulate aesthetic rules by these numbers. In twenty centuries, this procedure will be called 'scientific method' and the western world will have an unthinkable development. No doubt, the link between music and mathematics has to trace back to this man and his school and this work wants to investigate the transdisciplinarily period between the 6th and 3rd century B.C. In fact, the advices given by Pythagoras to his students continued for three centuries by Philolaus, Archita and others, but particularly by his wife Theanò, a mathematician, psychologist, manager and the first great female scientist of ancient times, who, together with their children, had a unique mission: the diffusion of their scientific thought. This paper is the beginning of a work in progress on the topicality of pythagorean thought and the importance today, more than ever, of the style of life of that school and its values. (Received September 14, 2012)

1086-K1-899 **Susan Happersett*** (fibonaccisusan@yahoo.com), 344 Grove Street #10, Jersey City, NJ 07302. *Fibonacci Drawing - Exploring the beauty of the Fibonacci Sequence through abstract drawing.*

The mission of my artistic practice is to present the aesthetic values of mathematics through a purely visual language. I have developed a drawing system of grids and counted mark making to express mathematical ideas as abstract art work. Before I start the process of making a drawing, I first make a plan that is written in a plan book and that contains all decisions and instruction to generate the drawing. Then I execute this algorithm by hand. The number of marks in each grid cell holds significance. The placement of the individual strokes in each cell is arbitrary. This type of drawing started with my interest in the Fibonacci Sequence. Fibonacci numbers are a recursively defined sequence. Each subsequent number is the sum of the preceding two numbers. This sequence has become my metaphor for growth. I made drawings, painting, artist's books and stop-motion animation videos based on this theme, exploring the number themselves, as well as the ratios of consecutive Fibonacci numbers and their patterns of self-similarity. I represent these aspects of the Fibonacci Sequence through the relative density of the markings that make up the drawing and proportions of the grids in the drawings. (Received September 15, 2012)

1086-K1-901 **Alexander J Hahn***, Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *The Gauss-Bonnet Theorem and the Sydney Opera.*

When its architect, Jorn Utzon, decided that he could take the design of the various triangular curving roof vaults of the Sydney Opera complex from a sphere of the same radius (246 feet), the Opera project was saved. This meant that all the vaults could be built as fan-like configurations of ribs that, because they curved in the same way, could be constructed from identical sequences of standardized rib segments. The concrete rib segments could be mass produced on site from molds. This would reduce cost, save time, and insure the feasibility of the project. When it came time for the outer surfaces of Utzon's spherical vaults to be covered by a sophisticated tile system, the question of the surface area of his spherical triangles became relevant. Had Utzon's triangles been geodesic (all sides lie on great circles), their surface areas would have been provided by Girard's Theorem. But Utzon's triangles are not geodesic (two sides do lie on great circles, but not the third). This fact connects the computation of the surfaces areas of Utzon's roof vaults to the Gauss-Bonnet Theorem of Differential Geometry. My presentation will describe this theorem and examine this connection. (Received September 15, 2012)

1086-K1-922 **Anneke Bart*** (barta@slu.edu), Dept of Mathematics and Computer Science, 220 N Grand Blvd; Ritter Hall 115, St Louis, MO 63103. *Teaching hyperbolic geometry using the works of Escher and Gaudi.*

Hyperbolic geometry can be taught in a freshman course using the work of Escher as a starting point. His circle limits are a wonderful illustration of the Poincare disk model. An additional collection of examples comes from the work of the Spanish architect Antoni Gaudi. This presentation will discuss ideas on how to make this topic accessible to freshmen. The materials are based on a course taught at Saint Louis University. (Received September 16, 2012)

1086-K1-929 **Frode Rønning*** (frode.ronning@hist.no), Sør-Trøndelag University College, Faculty of Teacher Education, Trondheim, Norway. *The Plastic (or Silver) Number.*

The Golden Ratio is one of the best known mathematical constants and its role in art and architecture is also well known. Probably less known is a number, in many ways closely related to the Golden Ratio, and most often referred to as the Plastic Number (sometimes also as the Silver Number).

This number is often linked to the Dutch monk Dom Hans van der Laan, who also was an architect, like his father and two brothers. In the architectural work of van der Laan the number appears as a ratio between dimensions, just as the Golden Ratio has been frequently used.

In this talk I will show some of Dom Hans van der Laan's work as well as going into the mathematics of the Plastic Number. An interesting observation is that The Plastic Number and the Golden Ratio share a particular number theoretic property. And even more interesting – these two numbers are the only ones that have this particular property! (Received September 16, 2012)

1086-K1-1020 **Barbora Kamrlova*** (kamrlova@fmph.uniba.sk), FMFI, Comenius University, Mlynska dolina, 84248 Bratislava, Slovak Rep. *When two colours suffice - even for children.*

We emphasise the bridge between mathematical and artistic vision and perception of the world, allowing children to discover mathematical concepts as on hand means to achieve non-mathematical artistic objectives, to answer their questions, emerging when exploring artistic topics and tasks - the plane paving/mosaic to be coloured by only two colours without any neighbourhood of the same colour fields. We show the connection between mathematics and arts with the discoveries in mathematics, unusual in the typical lower secondary school maths world. The need of mathematics, the topology and graph theory basis, emerged in 10-13-years old children spontaneously. Children found the chessboard, discovered an importance of the parity of edges for each vertice, the basic rules for graphs and used Jordanian closed curves as interesting enrichments. Compared to some discoveries (Piaget, Swoboda&Jagoda), there were two approaches to the problem. One part used static, mentally prefabricated chessboard variation. The considerable part of children employed the dynamical approach – continual generation of the curves, following the given topological rules, including Jordanian closed curves. After achieving their creation, none of the children had had an impression to have done any mathematics. (Received September 18, 2012)

1086-K1-1070 **Ann C Hanson*** (ahanson@colum.edu), Science/Math Dept., Columbia College, 600 S. Michigan Ave, Chicago, IL 60305. *Math/Art Course.*

In this session, the presenter will describe the course, Math in Art and Nature, which she teaches at Columbia College Chicago. The speaker developed this course in the mid 90's after attending an ISAMA Conference in Albany. This three-hour course meets once a week and attempts to find connections between mathematics and art. The name of the textbook, syllabus and grading system will be shared along with information and examples about the two creative math/art projects that the students make. In order to help the students find a project to do, part of the class is devoted to math/art activities and the other part to math. For example, the class learns about Fibonacci numbers and then later makes a quilt pattern based on Fibonacci numbers. Another example is after learning about fractals, the class makes a fractal pop-up card. Since there are many connections between origami and math, it is used in class whenever possible. The class makes an origami triangle box after discussing the properties of triangles. (Received September 18, 2012)

1086-K1-1152 **Kevin Lee*** (kevin.lee@normandale.edu), Bloomington, MN. *Intriguing Tessellation Animations in Real Time.*

Modern computer graphics cards have graphic processing units that can do several hundred million calculations per second. I will discuss and demonstrate my new algorithms that exploit this power to generate animations for creating Escher-like tessellations (tilings) of the plane. The animations dramatically show the geometry behind the tessellations. I will also briefly discuss how homogenous coordinates, linear algebra, computational geometry, computer graphics, and data structures all come together to create the algorithms behind the animations. My previous tessellations programs include TesselMania and Tessellation Exploration. (Received September 19, 2012)

1086-K1-1252 **Vladimir L Bulatov*** (info@bulatov.org), Corvallis, OR. *Bending Circle Limits.*

M.C.Escher's hyperbolic tessellations Circle Limit I-IV are based on a tiling of hyperbolic plane by identical triangles. These tilings are rigid because hyperbolic triangles are unambiguously defined by their vertex angles. However, if one reduce the symmetry of the tiling by joining several triangles into a single polygonal tile, such tiling can be deformed. Hyperbolic geometry allows a type of deformation of tiling, which is called bending. One can extend tiling of the hyperbolic plane by identical polygons into tiling of hyperbolic space by identical

infinite prisms. The prism's cross section is the original polygon. The shape of these 3D prisms can be carefully changed by rotating some of its sides in space and preserving all dihedral angles. Such operation is only possible in hyperbolic geometry.

The resulting tiling of 3D hyperbolic space creates 2D tiling at the infinity of hyperbolic space which can be projected into plane using usual stereographic projection. After small bending the original circle at infinity of the 2D tiling become fractal curve. Further bend makes the fractal to have thin tentacles, which join and create a fractal set of circular holes. Further bend closes the holes. See <http://bulatov.org/math/1209/> for illustrations. (Received September 20, 2012)

1086-K1-1307 **David J Schmitz*** (djschmitz@noctrl.edu), 30 N. Brainard Street, Naperville, IL 60613. *Teaching "Mathematics in Square Dancing"*. Preliminary report.

Since 2006, I have taught a two week course called "The Mathematics of Square Dancing" at North Central College. Square dancing, which has been described as mathematics on the dance floor, consists of a vocabulary of calls, each of which provides dancers with a precise set of instructions on how to transform themselves between formations, or to permute themselves within a single formation. Many square dance movements involve rotations, reflections, or translations; moreover, these movements start and end in various geometric configurations such as matrices, triangles, circles, diamonds, parallelograms, etc. Higher level square dancing requires mathematical thinking and sharp puzzle-solving skills to execute the unrehearsed choreography accurately and quickly.

In my class, I demonstrate how square dancing provides a way to visualize abstract mathematical concepts such as permutations, set partitions, group theory, and modular arithmetic. One doesn't have to be a mathematician to be an accomplished square dancer; however, knowing the mathematical connections to square dancing can provide dancers a deeper level of understanding and appreciation for the activity. (Received September 21, 2012)

1086-K1-1349 **Robert W Fathauer*** (tessellations@cox.net), 3913 E. Bronco Trail, Phoenix, AZ 85044. *Iterative Arrangements of Polyhedra – Relationships to Classical Fractals and Häüy Constructions*.

In a previously described structure, half-scale cubes were iteratively arranged around a central cube to yield a complex fractal "crystal" with a regular-octahedron convex hull and infinitely many "facets", each of which is essentially a Sierpinski triangle. In the present work, a Sierpinski triangle is shown to arise whenever half-scale polyhedra are iteratively arranged on three faces meeting at a vertex with three-fold rotational symmetry. In contrast, a regular array results when half-scale polyhedra are iteratively arranged on four faces meeting with four-fold rotational symmetry. These facts are used to predict which such arrangements will yield esthetically-pleasing results. The convex hulls of such constructs are the duals of the starting polyhedra for a variety of polyhedra. These arrangements can be thought of as Häüy constructions using a scaling factor of one half rather than one. One half is shown to be a special number for such scalings. When arrangements are made about vertices with five or six faces meeting with rotational symmetry, scaling factors of the square of the Golden mean and one third, respectively, result in fractals that can be described as a Sierpinski pentagon and a Sierpinski hexagon, the latter exhibiting Koch curves. (Received September 21, 2012)

1086-K1-1443 **Shahriar Piroozram, Sheida Riahi and Shantia Yarahmadian*** (syarahmadian@math.msstate.edu), Department of Mathematics and Statistics, Allen Hall 410, Mississippi State, MS 39762. *Golden Ratio: Ornamentations of Chehelsotoun, a Safavid Dynasty Palace in Isfahan, Iran*. Preliminary report.

The architecture of Safavid Dynasty is considered as the summit of this art in Iran. The beauty of the structures in this school is closely linked to the mathematical harmonies in the proportions of the building itself and also in the decorative elements. Chehelsotoun, a royal palace of this period, is chosen for the first time to examine such a relationship. In this study we will demonstrate how the Golden Ratio has been used in the ornamentations of this magnificent building. (Received September 22, 2012)

1086-K1-1559 **James Morrow*** (jmorrow@mtholyoke.edu). *Mathematics to Inspire Art to Inspire Mathematics to ...* Preliminary report.

The relationship between the arts and mathematics has been a source of fascination and inspiration to me for many years, and increasingly I have incorporated that relationship into my teaching and my other mathematical work. In this talk I first describe interactions between the arts and mathematics coming from my teaching a geometry course. Part of this course is intended to give students an experience with and vision of connections between mathematics and other disciplines and endeavors. The arts connection is something I have a personal commitment to and which is also supported by a campus-wide "creativity across the curriculum" project. I

illustrate a guided close observation by geometry students in an art gallery and I also describe a construction and design assignment in geometry in which students create two works having a common construction element, one with an artistic goal and the other a mathematical goal. Second, I describe a personal experience that started with the artistic goal of creating a present for a friend's birthday that led to a mathematical goal, which, in turn, led to a new artistic goal. (Received September 23, 2012)

1086-K1-1638 **Doug Dunham*** (ddunham@d.umn.edu), Department of Computer Science, 320 HH, 1114 Kirby Drive, Duluth, MN 55812-3036. *Patterns on Semi-regular Triply Periodic Polyhedra*. Preliminary report.

Several artists, including M.C. Escher have created patterns on symmetric closed polyhedra. However to our knowledge no one has created patterns on triply periodic polyhedra in Euclidean 3-space. We examine some patterns on triply periodic polyhedra, especially those satisfying some regularity conditions. We show some such patterns and explain how some of them are related to triply periodic minimal surfaces (TPMS). These patterns are also related to repeating patterns of the hyperbolic plane that are based on regular tessellations $\{p,q\}$ composed of regular p -gons meeting q at each vertex. We will explain these relationships, and examine some interesting geometric facts that link the patterns on triply periodic polyhedra, the corresponding TPMS's, and patterns of the hyperbolic plane. (Received September 23, 2012)

1086-K1-1827 **Margaret E Kepner*** (renpek1010@gmail.com). *Tiling the Plane with the Z-Pentomino: an Artistic Interpretation*. Preliminary report.

Polyominoes were formally introduced by Solomon Golomb in the mid-1950s. There are many examples of problems involving polyominoes including packing them in rectangles and other shapes, dissecting them into smaller copies of themselves (rep-tiles), and using them to tile the plane. The polyominoes of orders 2, 3, and 4 all tile the plane, and each can be shown to do so in an infinite number of ways. The situation with higher order polyominoes becomes more interesting. For example, directly congruent copies of the Z-pentomino will tile the plane in six, and only six, ways. These patterns are reminiscent of traditional Japanese textile pieces called sashiko. In this presentation, I will explain how I developed a design called "The Zen of the Z-Pentomino" employing these six tiling patterns in a style suggesting sashiko work. (Received September 24, 2012)

1086-K1-2017 **Radmila Sazdanovic*** (radmilas@math.upenn.edu), University of Pennsylvania, Department of Mathematics, 209 south 33rd street, Philadelphia, PA 19104-6395. *Diagrammatic calculus for research and teaching*.

Examples of the role of mathematics in art are numerous: perspective, symmetry, fractals, etc. We will discuss the role of diagrams and drawings in modern mathematics: their importance in research, teaching, and aesthetical value. A diagrammatic approach has been very useful in developing courses for non-mathematics majors, enticing and maintaining student's interest in learning mathematics. (Received September 24, 2012)

1086-K1-2066 **Darrah P. Chavey*** (chavey@beloit.edu), Beloit College, 700 College St., Beloit, WI 53511. *Euler's theorem and the "Plaited Mat" Sona Designs of Africa*.

The simplest form of the sona designs of the Chokwe (or Cokwe) people of Angola/Congo can be viewed as mirror curves in a rectangular grid, with lines passing through the rectangle at 45° angles and bouncing off the walls to form a closed curve. A well-known result is that the number of lines needed to complete the drawing in an $n \times m$ grid is $g = \text{g.c.d.}(n, m)$. Since all vertices of the drawing have degrees 2 or 4, Euler's theorem says there is a one-line drawing of that graph. An equivalent drawing is implemented by the Chokwe by placing mirror "walls" on some vertices so the curve bounces at those points, replacing an intersection with two curves, much like Bain's constructions of Celtic knots. A consequence of Euler's theorem is that the minimum number of such walls needed to create a one-line drawing is $g - 1$. But the artistic ideal of the Chokwe requires that the resulting drawing should be symmetric. It is always possible to construct symmetric sona using many such mirrors, but we ask when this is possible using the minimal number of such interior "walls". The result is that it is always possible for mirror symmetry, sometimes for rotational symmetry, and never for double mirror symmetry. The results include a variety of attractive, symmetric sona designs. (Received September 24, 2012)

1086-K1-2214 **Reza Sarhangi*** (rsarhangi@towson.edu), Department of Mathematics, Towson University, Towson, MD 21252. *The Art and Mathematics of Tiling and Tazhib for the Interior of Some Special Star Polygons*. Preliminary report.

This presentation is about possible approaches for tiling inside of some star polygons, such as a pentagram and a decagram, which have been constructed using (n, k) star polygons, where n and k are relatively prime. This presentation also includes the unconstructible heptagon and an ancient approximation for its construction. The talk then analyzes an actual heptagram tiling on the wall of an existing structure. Moreover, some topics in

the art of Tazhip and the use of spirals will be presented, which include the use of pentagonal spirals in the heptagram. During this talk some related mathematical artworks will be shown. (Received September 25, 2012)

- 1086-K1-2269 **Monica VanDieren*** (vandieren@rmu.edu) and **Heather Pinson** (pinson@rmu.edu), Robert Morris University. *Discovering Connections Between Modern Mathematics, Music and Art.*

This presentation will describe an interdisciplinary honors course created and team-taught by a mathematician and musician at Robert Morris University. The biennial course attracts students with varied experience and interest in mathematics and music.

We organized the course around four themes: symmetry, infinity, searching for truth, and improvisation and incorporated examples from the late nineteenth and early twentieth centuries. Focus was placed on the development of mathematical logic and the transition in music from the Romantic period to avant-garde. Art was used as a bridge to visualize and conceptualize the more abstract mathematical and music theoretic content.

A main course objective was to examine major developments in mathematical and musical history that utilize the creative process as a way to incite new ideas. Then, we assessed the students' understanding of the creative process in two final projects: 1. students examined what the creative process means in their own majors, and 2. students found other evidence of the creative process used in disciplines outside of their academic training such as poetry, photography, pop music, clay models, musical performance, java applets and animations. (Received September 25, 2012)

- 1086-K1-2306 **Jeffrey J Beyerl*** (jeff.beyerl@furman.edu). *Optimizing balance in video games with asymmetrical choices.*

Video games are a pervasive part of society and a growing multi-billion dollar industry. With the volume of new games produced, manufacturers are developing more content and allowing players more customization of their gameplay. A current trend is to give players multiple asymmetrical styles of play to choose from. Ideally each of these play styles are time-balanced so that there is no obvious "best" style. In this talk I will give a method for balancing varying strategies in action role-playing games: games in which the player develops a single character focused on eliminating computer-controlled opponents as quickly as possible. (Received September 25, 2012)

- 1086-K1-2321 **Carissa M Brtalik*** (carissabrtalik@yahoo.com), 401 Ocean Avenue, Malverne, NY 11565. *Algorithms for Creating Self-Similar Curves and Surfaces in \mathbb{R}^3 .* Preliminary report.

We explore a technique for constructing self-similar planar curves from smooth base curves, originally introduced by Craig Kaplan, which result in a fractal-like structure. We then extend this work to curves and surfaces in \mathbb{R}^3 , discuss their mathematical properties, and visually demonstrate the results of these algorithms on a number of aesthetically pleasing examples. (Received September 25, 2012)

- 1086-K1-2722 **Shirley Yap***, shirley.yap@csueastbay.edu. *What's in an octave?* Preliminary report.

Scales are ways to divide the set of frequencies between a given note and the octave above it. We can use the concept of frequency doubling and symmetry to attempt to construct a scale. This activity (which has a lab component to it), can be used to teach exponential functions, symmetry and invariance. (Received September 25, 2012)

- 1086-K1-2733 **Rita Capezzi*** (capezzir@canisius.edu), Department of English, Canisius College, Buffalo, NY 14208, and **Christine Kinsey** (kinsey@canisius.edu), Department of Mathematics, Canisius College, Buffalo, NY 14208. *Joining "the mathematician's delirium to the poet's logic": Interdisciplinary Teaching and Constrained Writing in the Canisius College All-College Honors Program.* Preliminary report.

We found it enjoyable and productive to introduce students to a wide range of mathematical concepts with applications to and overlap with literary constructs. We began with the OULIPO movement, which introduced the axiomatic approach to both mathematics and writing. Students read Georges Perec's *The Art of Asking Your Boss for a Raise*, which led to a discussion of flow charts, computers, and the Halting Problem. Berge's story "Who Killed the Duke of Densmore" led to an investigation of interval graphs. Stoppard's play *Arcadia* gave us many rich opportunities to discuss Fermat's Last Theorem, determinism, entropy, and chaos theory. Circle-packing problems and the fourth dimension came up in Robbe-Grillet's *Jealousy*. Stories by Borges brought up topics including computation, the Infinite Monkey Theorem, probability, and mazes. We read excerpts from Perec's *Life: A User's Manual*, with digressions on knight's tours and Graeco-Latin squares. Italo Calvino's *If on a winter's night a traveler* brought us to paper folding, book imposition, and kaleidoscopes. From a literary critical perspective, the course highlighted the play of language rather than the primacy of meaning, with special

focus on how mathematics as both subject and metaphor structures the literary object. (Received September 25, 2012)

1086-K1-2780 **Karl Schaffer*** (karl_schaffer@yahoo.com). *Mathematics and Ballet*.

Like many dance forms classical ballet uses codified movements, body positions and stage arrangements. We will look at mathematical aspects of a variety of ballet movements, sequences, and body positions. For example, the Fibonacci numbers and a variety of recursions arise in the ballet barre, a standard set of warm-up exercises at the beginning of the traditional ballet class. Ballet teachers often generate a large number of barre exercises from the simplest tendu movements. Symmetry principles also illuminate other aspects of this dance form including standard body placement and choreographed dance sequences. We will also look at how ballet contrasts or resembles several other classical dance forms with respect to these mathematical concepts. (Received September 25, 2012)

1086-K1-2788 **Charlene Morrow*** (cmorrow@mholyoke.edu). *Pascal's Palette: Artworks Inspired by the Numbers 70 and 84*.

In a paper written for the 2012 Bridges Math/Art Conference, I describe and discuss the use of combinatorial mathematics as a tool for coloring an origami quilt with 70 units. This challenge arose from my desire to create a subtle and interesting, mathematically based birthday gift for a friend who was turning 70. In this presentation I will describe how the ideas I used to create the origami quilt inspired by 70 led me to create a completely different piece of art centered around 84 — the next birthday gift I needed. The “70” quilt used non-regular pentagonal pieces of paper to fold into the triangular-shaped quilt pieces. I observed that the unfolded pentagons tessellate, and that 4 pentagons could be combined into non-regular hexagons (which also tessellate, of course). Thus 21 hexagons use 84 pentagons. Since 84 appears in Pascal’s triangle, I was able to devise an interesting combinatorial coloring scheme for the “84” piece. I will summarize the mathematics used and design steps leading to the final print on paper, a result that was produced through the interplay between mathematical ideas and artistic goals. (Received September 25, 2012)

1086-K1-2836 **David A. Reimann*** (dreimann@albion.edu), Math/CS Department, Albion College, 611 E. Porter St., Albion, MI 49224. *Point Symmetry Patterns on 1-Uniform Tessellations*.

The results from an investigation of point symmetry patterns on the eleven 1-uniform tessellations is presented. Five of the 17 plane symmetry groups are represented by these tessellations: *632, *442, 632, 4*2, and 2*22. Each of these plane symmetry groups has three point symmetry groups. Each of these point groups contains a collection of subgroups; each subgroup corresponds to a symmetric pattern. However, the restriction to the underlying tessellation causes some symmetry subgroups to be repeated. In particular, the plane symmetry groups having multiple dihedral point groups (*632, *442, and 2*22) contain mirror lines that are shared among their respective point subgroups, resulting in rotationally equivalent symmetry patterns. Specific types of decorated polygonal tiles are required to achieve a particular point symmetry group using a given tessellation: tiles containing a single mirror line either through opposite edge midpoints, opposite vertices, or through an edge midpoint and an opposing vertex. In point symmetry groups centered at a polygon center, the central polygonal tile decoration must also match the point symmetry of the entire pattern. Examples of the geometrically unique symmetric patterns are shown for each tessellation. (Received September 25, 2012)

1086-K1-2897 **Mark Kozek*** (mkozek@whittier.edu), Department of Mathematics, Whittier College, Whittier, CA 90608-0634. *A Freshman Writing Seminar on Mathematics*. Preliminary report.

In this preliminary report we reflect upon our experience teaching a freshman writing seminar using reading material about mathematics.

Mathematicians, more so than any other academics in modern lore, seem to lead extraordinary lives that blur the boundaries between fact and fiction. They include a French political radical who died in a duel at the age of 20, a British code-breaker who built the machine that cracked the Nazi’s ENIGMA cipher during World War II then lost his security clearance for being homosexual, and Ukrainian siblings who chased and caught a unicorn in a small castle in Manhattan — all of whom have been immortalized in writing or on film.

In this freshman writing seminar students will examine some of these amazing mathematical characters, their fictional alter egos and the issues, mathematical or otherwise, inherent to their stories. Using sources that include literature, historical texts, films, and documentaries, students will work from a model of writing that emphasizes logical structure, deductive reasoning, critical thinking, and proper citation. (Received September 26, 2012)

1086-K1-2910 **J Brooke Ernest*** (brookeernest@gmail.com) and **Ricardo Nemirovsky** (nemirovsky@sciences.sdsu.edu), 6475 Alvarado Road, San Diego, CA 92120.

Intersections: Undergraduate students' engagement with projective geometry and the arts.

We teach an undergraduate course on projective geometry in which students explore connections with art. Starting from the classic problem of linear perspective to create “realistic” images, we extend affine planes onto projective planes. Students learn to prove synthetically with axioms for RP^2 and RP^3 . The last section of the course reconstructs several theorems analytically through the use of homogeneous coordinates. During the course, students analyze different types of paintings and create their own paintings with airbrushing techniques. In this presentation we discuss recorded conversations with students in this course before, during, and after a field trip to a museum of contemporary art. While the historical and technical relationships between projective geometry and realistic paintings or photographic images are easy to recognize, the students' work and analysis of contemporary art poses open-ended and non-trivial questions for them regarding more general connections between mathematics and the arts. In particular, their simultaneous engagement with projective geometry and contemporary art can lead to important insights about the expressive potential of mathematics and the cultural value of conceptual art. (Received September 26, 2012)

1086-K1-2932 **Elizabeth C. Rogers*** (brogers@piedmont.edu), Department of Mathematics, Piedmont College, 165 Central Ave., Demorest, GA 30535. *A Visual Tour of Lesser Known Art and Architecture as Examples of Mathematical Development of World Civilizations.*

In teaching a non-Eurocentric mathematics history course, one must frequently rely on the visual art forms as a starting place for discussion of the mathematical development of many civilizations. This presentation will focus on some of the world's lesser visited sites that provide evidence of the mathematical achievements of various regions and civilizations as evidenced in art and architecture. The visual tour will feature the presenter's original research and photographs of sites including: the Chimu adobe village of Chan Chan and Moche Temples of the Sun and Moon in Peru; the Mosque at Cordoba, Spain; Tower of Homage at Gibraltar, the Museum of Mathematics at Sharjah, UAE; Yonghe Temple and the Capital Museum in Beijing. (Received September 26, 2012)

1086-K1-2963 **William C Kronholm*** (wkronholm@whittier.edu), Department of Mathematics, Whittier College, Whittier, CA 90608. *On Homology Preserving Representations of Planar Rips Complexes.* Preliminary report.

In this preliminary report, we explore the following problem: Given a network of n nodes, can one choose coordinates x_1, \dots, x_n in \mathbb{R}^2 so that the projection of the Rips complex determined by the communication graph of the sensor nodes to \mathbb{R}^2 induces an isomorphism between the homology of the Rips complex and the homology of the image of the projection? Can the coordinates x_1, \dots, x_n be chosen so that the projection is an isomorphism for all possible communication graphs? If not, what additional information is needed to guarantee the projection induces an isomorphism?

This problem is inspired by a collaboration between artist and mathematician and the connection between the art and the mathematics will be discussed. (Received September 26, 2012)

Mathematics and Sports

1086-K5-21 **Eva G Sagan*** (egsagan@manchester.edu), 604 East College Avenue, North Manchester, IN 46962. *Applications of Basic Statistics in World Cup Soccer between 1930 and 1990.* Preliminary report.

This paper plans to demonstrate applications of basic statistics during the games of the World Cup Soccer Competitions held between 1930 and 1990. Data was collected for the top twenty scoring men's World Cup Soccer teams during this time period. From the data we determined the mean, median, standard deviation, skew direction, quartiles, and outliers. An historical overview for World Cup Soccer games during this time period will also be presented in order to understand why outliers existed. A statistical analysis summary will be provided which may give a fuller understanding of World Cup Soccer games. The pedagogical merits of teaching statistical concepts through sports will be emphasized. (Received May 08, 2012)

- 1086-K5-267 **Tetyana Berezovski** (tberezov@sju.edu), St. Joseph's University, Department of Mathematics, 5600 City Ave, Philadelphia, PA 19131, and **Diana S Cheng*** (dcheng@towson.edu), Towson University, 8000 York Road, Towson, MD 21252. *Using Figure Skating Activities to Develop Middle School Teachers' Rational Number Sense.*

The Common Core State Standards place emphases on middle school students' understandings of multiple representations of ratios, rates, and proportions. Much research has documented students' struggles with developing such conceptual understandings. In order to motivate students to overcome their difficulties with learning rational numbers, teachers must provide not only meaningful mathematical but also motivational learning environments. Figure skating can be used in interdisciplinary contexts in which rational number sense can be taught. In this presentation, we will use figure skating topics such as the International Judging System and pairs skating through the lens of proportional reasoning. We will also discuss possible ways that teachers can motivate their students to learn challenging mathematical concepts through popular sports. (Received August 14, 2012)

- 1086-K5-708 **Brian Pasko*** (brian.pasko@enmu.edu), ENMU, Station 18, Portales, NM 88130, and **Tom Brown** (tom.brown@enmu.edu), ENMU, Station 18, Portales, NM 88130. *Winning a Racquetball Match.*

We derive a combinatorial formula for the probability of winning a game of racquetball to any score k given the probabilities that each player wins a point while serving. We extend this result to winning a best of three match. If a third game is required, the player scoring the most points in the first two games serves first. This unique rule for choosing the first server in a deciding game adds a wrinkle to predicting the winner of a match not present in other racquet games. (Received September 11, 2012)

- 1086-K5-906 **Scott B. White*** (scott.white@saintleo.edu), Saint Leo University, Department of Mathematics and Sciences, MC 2188, Saint Leo, FL 33574, and **Jacci White** (jacci.white@saintleo.edu), Saint Leo University, Department of Mathematics and Sciences, MC 2188, Saint Leo, FL 33574. *A Mathematical Model Of A Volleyball Serve, From Projectile Motion To Fluid Dynamics.*

In this session we will begin with defining the environment to lay it out in a coordinate system. Next we will construct the equations of motion for the optional path before considering wind resistance. Of course, we are not done until we take into account spin and drag and finally, the unstable aerodynamics of the "floater" serve. (Received September 15, 2012)

- 1086-K5-1069 **Ben S. Baumer*** (bbaumer@smith.edu), 217 Prospect St, Northampton, MA 01060, and **James Piette** and **Brad Null**. *Parsing the Relationship between Baserunning and Batting Abilities within Lineups.*

A baseball team's offensive prowess is a function of two types of abilities: batting and baserunning. While each has been studied extensively in isolation, the effects of their interaction is not well understood. We model offensive output as a scalar function f of an individual player's batting and baserunning profile z . Each of these profiles is in turn estimated from Retrosheet data using hierarchical Bayesian models. We then use the SimulOutCome simulation engine as a method to generate values of $f(z)$ over a fine grid of points. Finally, for each of several methods of taking the extra base, we graphically depict the surface $f(z)$ over changes in the probability of advancing via that method. This framework allows us to draw conclusions both about optimal baserunning strategies in general, and about how particular offensive profiles affect a player's optimal baserunning strategy. We present many informative visualizations and analyze specific aspects of several well-known Major League players. (Received September 18, 2012)

- 1086-K5-1196 **Michael A. Jones*** (maj@ams.org), Mathematical Reviews, American Mathematical Society, 416 Fourth Street, Ann Arbor, MI 48103, and **Laura VerHulst** (11v10@albion.edu), Albion College, Albion, MI 49224. *The National Football League's Overtime Rule Revisited.*

On January 8, 2012, the Denver Broncos defeated the Pittsburgh Steelers in the first use of a new overtime rule that the National Football League (NFL) instituted for the playoffs the year before. Under the old rule, sudden death, the first team to score wins the game. The new rule offsets the first-possession advantage of sudden death by allowing the game to end on a single possession only if the team with the ball first scores a touchdown. This rule was adopted for the 2012 regular season.

Using aggregate data from the 2011 regular season and Markov chain models in which each team has equal probabilities of scoring on each possession, we compare the new rule, sudden death, and a previously proposed first-to-six rule by computing the likelihoods of the team receiving the ball first wins. We construct a more detailed Markov chain model to compare the likelihood of the first-possession team winning under asymmetric

probabilities of scoring. We apply the model with team data from the 2011 season. (Received September 20, 2012)

1086-K5-1380 **Daniel L Summers*** (danielsummers@mail.adelphi.edu), 8828 249st, Bellerose, NY 11426. *Google's PageRank Algorithm and its Application to Major League Baseball Transactions.*

Google's PageRank Algorithm was created by Sergey Brin and Larry Page in 1996 in an effort to improve the ability of computers to search for information. It seeks to find the relative importance of each website to be better able to return relevant searches to a given query. This algorithm, while intended for use on the World Wide Web, has found uses in ranking doctoral programs, analyzing traffic patterns, and determining importance of species in an ecosystem. With Major League Baseball's new reliance on heavily mathematical analysis of players and the internet hyperlink-like structure of players in teams, it opens the door for PageRank to be applied to the MLB and for analysis of what the "most important team" actually means. We present the results of applying this algorithm to player transactions between teams and interpret the resulting rankings of teams. (Received September 21, 2012)

1086-K5-1853 **Paul R. Bouthellier*** (pbouthe@pitt.edu), 504 East Main Street, Titusville, PA 16354. *Numerically Approximating the Flight of Baseballs and Footballs.* Preliminary report.

The problem that we shall examine in this talk is that of the trajectory of objects such as baseballs and footballs. We shall analyze their flight trajectory, maximum height, and distance traveled. We shall estimate the mass and cross-sectional area of the object, consider the initial velocity and acceleration of the object, the spin of the object, the coefficient of drag, and the effects of the wind. The solution of the corresponding differential equations will be approximated and rendered in a 3D graphics package allowing students to see the flight path in R3 from any position and angle in R3. The objects will be mathematically modeled in the graphics package Studio 3D Max. The model consists of a triangular mesh made up of vertices. Using these vertices and a density function, the surface area, volume, mass, and cross-sectional area of the object will be approximated. Using these cross-sectional area and mass approximations, as well as the above mentioned factors, approximations of the flight equations are derived using Runge-Kutta methods. The effects of wind and the coefficient of drag on the distance traveled and the maximum height of the object are studied via simulations. (Received September 24, 2012)

1086-K5-1958 **Timothy Chartier, Donour Sizemore and Erica Dominic*** (erica.dominic09@kzoo.edu), 1307 Hicks Center, Kalamazoo, MI 49006. *Interpreting Imperfect Data to Perfect Performance in a NASCAR Race.*

Perhaps more than any other sport, auto racing requires finely tuned, complex technology in order to successfully compete. Despite that, telemetric data collection from the car itself is limited during a NASCAR race, and the team must rely on qualitative assessments from the driver as to the security of the wheels on the car. During a pit stop, however, the pit crew has a few crucial seconds to replace the old tires with new ones, each of which is secured by five lug nuts tightened with a pneumatic impact wrench. The time-varying pressure of this impact wrench can be recorded. The goal of our research was to automate the process of detecting tightened lug nuts based on the pressure data from this impact wrench, and the program successfully does so by manipulating the data with a Savitzky-Golay data smoother and convolution algorithm. Thus this program offers more information about the mechanics of the car where direct measurement is impossible, and can be used in real-time during a race to make judgments concerning the car and appropriate winning strategies. (Received September 24, 2012)

1086-K5-1995 **J. Christopher Tweddle*** (ct55@evansville.edu). *Should I get new wheels? The effects of rotational versus non-rotational mass in bicycling.*

A common adage in road cycling is that "a gram off the wheels is two grams off the frame." That is to say, moving the wheels takes twice as much energy as moving the frame and rider, since energy is required to both rotate and propel the wheels forward, whereas the the frame and rider merely move forward. We will use fundamental principles from physics to explore the energy savings of lighter wheels as compared to a lighter frame and rider. We will conclude by putting any savings into perspective by comparing this savings to other forces acting against the cyclist, such as wind resistance and friction. (Received September 24, 2012)

1086-K5-2126 **Jeffrey W. Heath*** (jeffrey.heath@centre.edu), 600 W. Walnut St., Danville, KY 40422, and **Sophie Han.** *A New Basketball Shooting Efficiency Metric.*

Field Goal Percentage (FG%) has been widely used to measure a player's shooting ability due to its simplicity. However, FG% overlooks the effect of space, and thus it is often a misleading indicator of how well a player actually shoots. We develop a new metric, Effective Points Gained (EPG), that takes the shot distance and

location into account, and computes each player's marginal points gained for each shot. The final result gives a better understanding of a player's shooting efficiency. Results from NBA data will be presented. (Received September 24, 2012)

1086-K5-2234 **Andrew B Perry*** (perryand@gmail.com), Springfield College MPCs Dept., 263 Alden St., Springfield, MA 01106. *Mathematical Analysis Raises Questions About The Wisdom of Conventional Decision Making In Sports.*

As more sports data becomes widely available to the public, there has been increasing debate over the apparent foolishness of certain commonly used strategies in sports. For example, many numerate baseball fans feel that the bunt in baseball is overused. In football, data suggests that the punt is overused, and that fourth down conversions should be attempted in many more situations. In these two scenarios and others, we will consider how the mathematical data can be interpreted to suggest that managers and coaches are chronically foolish. We also note unquantifiable psychological factors that coaches can and do cite as arguments to disregard the apparent mathematical conclusions. (Received September 25, 2012)

1086-K5-2407 **Roland Minton*** (minton@roanoke.edu). *Putting on the PGA Tour.* Preliminary report. A model for the trajectory of a golf putt is introduced, with parameters matched to PGA golf tour statistics. The model takes into account both golfer error and imperfections on the greens. The model and the PGA's statistics are both used to address the question of how large a role consistency plays in putting success. Examples will be given of specific golfers and how their performance varies over time. (Received September 25, 2012)

1086-K5-2408 **Nicholas Gorgievski*** (nick.gorgievski@nichols.edu), Center Road, PO Box 5000, Dudley, MA 01571, and **Thomas C. DeFranco** (tom.defranco@uconn.edu), 249 Glenbrook Road, Unit 2064C, Storrs, CT 06269. *The NFL Overtime Rule Change: Was it really necessary?*

Over the past decade, football fans, sportscasters, writers, and mathematicians had all weighed in on whether the NFL "sudden death" overtime rule was fair to both teams. Many had claimed that the winner of the coin toss had an advantage in winning the game. As a result of all of the debate, the NFL owners accepted a proposal to alter the overtime rule for postseason games beginning in the 2010-2011 football season and for regular season games beginning in the 2012-2013 season. However, was this rule change really necessary? In this session, we use logistic regression to examine the coin toss and its effect on the outcome of "sudden death" overtime games prior to the 2012-2013 season. Additionally, we describe how the NFL kickoff rule change, initiated at the beginning of the 2011-2012 NFL season, may have a greater impact on overtime games. (Received September 25, 2012)

1086-K5-2470 **R. Drew Pasteur*** (rpasteur@wooster.edu) and **Kyle Cunningham-Rhoads.** *A Value-Added Metric for NFL Field Goal Kickers.* Preliminary report.

Using game-situation information and weather data for each field goal attempt during several recent NFL seasons, we attempt to identify the key factors in kicking success. To quantify their influence, we fit a multivariate model for the success probability of a particular field goal, if attempted by a generic NFL kicker. This leads to an intuitive metric for an individual kicker's performance, based on the degree to which he exceeds (or falls short of) the expected aggregate result. In applying this metric, we explore the common belief that NFL kickers are mostly interchangeable. (Received September 25, 2012)

1086-K5-2711 **Brian A Macdonald*** (bmac@jhu.edu), United States Military Academy, Department of Mathematical Sciences, West Point, NY 10996. *Measuring and Predicting Performance in Hockey.*

We present different ways that one can measure and predict performance in hockey. Since goal scoring can be fairly random, it is not always best to use goals by themselves for this purpose. We present ways in which one can use other statistics along with goals to achieve better results. (Received September 25, 2012)

Mentoring Graduate Students: Pathways to Success

1086-L1-356 **Donna J. Dean*** (donnajdean22@gmail.com), 1321 Duke Street, Suite 210, Alexandria, VA 22314, and **Cynthia L. Simpson** (simpson@awis.org), 1321 Duke Street, Suite 210, Alexandria, VA 22314. *How to Develop Your Mentoring Network: Critical Skills for a Life-Long Career.*

This workshop will focus on practical tools and strategies that individuals can implement in finding the right mentors for the twists and turns that will inevitably occur over a career's trajectory. Now, more than ever,

it is imperative that mathematicians take an active role in selecting appropriate mentors for ourselves and in developing our mentoring networks. Effective mentoring can enable any individual who has a passion for mathematics to find her or his own 'best fit' for a career that melds life and career values. Because few individuals will have a perfect pathway to a career in mathematics or a seamless meshing of career into the other aspects of life, it is necessary to develop our own toolkits to navigate through these complexities. Pragmatic points will be presented that will help participants clarify what aspects they wish to address with mentors. How to identify the most appropriate mentors will also be a key part of the workshop. Different life experiences, workplace settings, family frameworks, and individual aspirations make it imperative to seek out a range of mentors. Participants will engage in interactive discussion on those aspects which have resonance in their own lives and careers. (Received August 24, 2012)

1086-L1-363 **Leslie Hogben*** (hogben@aimath.org), Department of Mathematics, Carver Hall, Iowa State University, Ames, IA 50011. *EDGE@ISU*.

EDGE@ISU is a mentoring cluster at Iowa State University that is part of the national EDGE (Enhancing Diversity in Graduate Education) program. The goals of EDGE and EDGE@ISU are strengthening the ability of women students, especially those in minority groups, to successfully complete graduate programs in the mathematical sciences and have successful careers. EDGE has operated a successful summer bridge program for more than ten years. Continued mentoring has always been an essential ingredient of the summer program, and more recently EDGE expanded its mentoring component to include regional mentoring clusters. The EDGE Mentoring Clusters address the need for continued mentoring for graduate students, post-doctoral associates, and junior faculty. The cluster meetings and relationships developed provide members with a forum to discuss academic and non-academic issues that may impact their careers. The EDGE@ISU cluster is led by Leslie Hogben, Professor of Mathematics and Karin Dorman, Associate Professor of Statistics. This talk will describe EDGE@ISU and additional mentoring that it has helped develop. See also <http://orion.math.iastate.edu/lhogben/EDGEatISU.html> (Received August 25, 2012)

1086-L1-989 **Brooke Shipley***, University of Illinois at Chicago, 508 Science and Engineering Offices (m/c 249), 851 S. Morgan Street, Chicago, IL 60607-7045, and **Manorama Khare**. *Preparing STEM URM Postdoctoral Associates for Faculty Positions - A Replicable Model to Increase Diversity in Faculty Ranks*.

The WISEST (Women in Science and Engineering System Transformation) program at UIC has several mentoring programs. With support from an NSF ADVANCE grant, we ran a two year pilot program, developed collaboratively with the National Postdoc Association, for five underrepresented minority women in STEM with the goal of providing mentoring to prepare for the academic job search and for the challenges of being a beginning investigator. We matched the research interests of the postdocs with a multi-member mentoring team and provided monthly skill building seminars. We will describe this postdoc mentoring program, its assessment and the lessons learned. If time allows we will also discuss our mentoring program for assistant professors modeled on the monthly skill building seminars. (Received September 17, 2012)

1086-L1-2903 **Sarah E. Eichhorn*** (sfrey@math.uci.edu), 340 Rowland Hall, Department of Mathematics, University of California, Irvine, Irvine, CA 92697. *Future Mathematics Faculty Program at UC Irvine*. Preliminary report.

In order to help prepare graduate students for academic faculty positions, the UC Irvine Mathematics Department recently created our Future Mathematics Faculty Program. This program gives our students an opportunity to 1) interact with faculty at a range of academic institution types, 2) improve their mathematical presentation skills, and 3) develop their teaching pedagogy training.

We have 8 local college partners who agree to host our graduate students to give a general audience colloquium talk in their mathematics department. The graduate students in our program work with a small faculty team in preparing engaging, accessible talks on their research or field. The students then have the opportunity to give this talk at several of our partner colleges. When visiting each school, the students have the opportunity to interact with the faculty and discuss the faculty worklife at that institution.

In addition to this talk experience, grad students are also given the opportunity to earn a "teaching certificate" by completing training activities in 5 areas of professional development in education.

In this talk we will discuss the logistics of these programs as well as the impact on our graduate student success in getting hired for and excelling in faculty positions. (Received September 26, 2012)

Philosophy, Mathematics, and Progress

1086-L5-45 **Amy Ackerberg-Hastings*** (aackerbe@verizon.net). *John Playfair, the Scottish Enlightenment, and "Progress" in the History and Philosophy of Mathematics*. Preliminary report.

The thinkers of the Scottish Enlightenment were fascinated by the concept of progress, both in human history and in the development of the natural world. Commentators, especially popular writers, have noted that the Scots' optimism about progress established a foundation for 21st-century assumptions about the nature of this concept. Toward the end of the Scottish Enlightenment, John Playfair (1748-1819), a younger contemporary of the principal Edinburgh figures of the movement, joined the conversation. In particular, in 1816 he penned "Dissertation Second: On the Progress of Mathematical and Physical Science Since the Revival of Letters in Europe" for *Encyclopaedia Britannica*. This talk provides some historical background for the session by describing how this University of Edinburgh professor of mathematics and then of natural philosophy understood the meaning and role of progress in mathematics and its history. The talk will also suggest how paying attention to the complexities of this concept can benefit today's teachers. (Received June 21, 2012)

1086-L5-71 **Sean F Argyle*** (sargyle1@kent.edu). *Mathematical Thinking - From Cacophony to Consensus*.

What does it mean to do mathematics? What counts as mathematics? Who decides? These sorts of fundamental questions about the nature of the discipline have not yet been answered such that there is general agreement on the matter. Without these answers, how can we trust in our derivations and proofs? More importantly, how can we train the next generation of mathematicians if we can't even agree what it means to be a mathematician? What little research on the subject exists is disjointed and dissenting, leading some researchers to lament the possibility of ever coming to an agreement on how to define "mathematical thinking" as a viable construct. Rather than add one more voice into the cacophony of competing definitions, this presentation seeks to discuss the results of a meta-analysis of the term's use in an appropriately titled journal – *Mathematical Thinking and Learning*. This synthesis of more than a decade of research provides cognitive model of the internal process of doing mathematics utilizing a post-epistemological stance that relies on a compromise between the Platonist and Formalist extremes. Only when researchers and philosophers can agree on a vocabulary can we begin to "stand on the shoulders of giants." (Received July 04, 2012)

1086-L5-209 **James R. Henderson*** (henderson@pitt.edu). *Progress in Mathematics: The Importance of Not Assuming Too Much*.

John Stuart Mill took mathematics to be just another natural science. Exploiting this point of view, one may give a Mill-style analysis of the progress in mathematics in light of the literature written on the progress of other natural sciences. There is no more influential work on the progress of science than Thomas Kuhn's *The Structure of Scientific Revolutions*. One of the planks in Kuhn's platform is that after a scientific revolution the new paradigm is incommensurable with the old one. In part this means the new theory is not simply a generalization of the old theory. Kuhn claims that this is due to the fact that the terms of the old theory are grandfathered into the new one, but some of them are used in different ways. I argue that at least some post-revolutionary mathematical theories are incommensurable with pre-revolutionary theories, but for a different reason – because important operating assumptions of the old paradigm are dropped. Mill would not have been surprised when physicist David Bohm observed that dropping assumptions was the key to scientific advancement, providing another parallel between mathematics and (other) natural sciences. (Received August 07, 2012)

1086-L5-365 **Ruggero Ferro*** (ruggero.ferro@univr.it), c/o Dipartimento di Informatica, Università di Verona, Strada Le Grazie 15, 37134 Verona, VR, Italy. *Mathematics vs Philosophy*.

I claim that the mismatch between the progress in mathematics and in philosophy is not surprising.

- 1) Philosophy's desire to answer the most fundamental questions of humankind is perhaps too ambitious.
- 2) OK Scire per causas. But how to detect the causes of the situation that we experiment?
- 3) Philosophy touches upon very sensitive topics such as personal beliefs, morality. Here the arguments to reach an agreement are not only deductive.
- 4) Epistemological views are introduced within a theoretical system, and not beforehand to justify it. Can a philosophy accept that we cannot justify everything, due to the human limitations? On the other hand mathematics is more humble, if not coward.
 - a) No one claims to know exactly the meaning of the axioms.
 - b) Various principles are used, but don't ask why they should be accepted.
 - c) Proofs should be easily checked, but no one cares how they were devised.

d) Mathematics is a good organization of multiplicity: by dropping information, a situation becomes manageable.

e) What is mathematics? is a question dismissed as non-mathematical.

The role of language is central to many of these points.

To face some previous point, the internal non-physical experience is needed. (Received August 25, 2012)

1086-L5-459 **Deborah C. Arango*** (deborah.arango@ucdenver.edu), 1250 14th Street, Denver, CO 80217. *From Intuition to Esoterica.*

Wisdom is not mere knowledge nor the ability to acquire and synthesize a body of apparently useful facts. Since antiquity wisdom has been valued as an insight into truth; which itself transcends wisdom. When we study mathematics we begin to understand the intrinsic relationship between these two hierarchal realms, and the revelations that can be gleaned from them. I will argue that the methods and information discovered from the process of Science is ultimately approximative and protean. On the other hand, the transcendent arena – which is the domain of mathematical principles, enjoys a kind of perdurition through time. Therefore the very methods and devices of science alone are inadequate to the task of examining it. However there should never be any disparity between the facts, gleaned by science, and the insights, revealed by mathematics, which in turn transcend mere knowledge. Indeed, Mathematics has always given us insight into the reality of things – even those which elude us empirically – from imaginary numbers to black holes, so that even when we lack the faculty to observe things we can know their existence simply because they ought to exist, Mathematically. (Received September 03, 2012)

1086-L5-618 **Thomas Drucker*** (druckert@uw.edu), Dept. of Mathematical and Computer Sciences, University of Wisconsin–Whitewater, Whitewater, WI 53190. *Mathematical Progress via Philosophy.*

Mathematicians complain about the extent to which questions in the philosophy of their subject remain unaltered after thousands of years, while the discipline of mathematics itself seems to make indubitable progress. This talk looks at some of the issues in the philosophy of mathematics, from Aristotle to the twentieth century, that have led to advances within mathematics itself. The philosophical questions do not have to be resolved in order for work on them to contribute to mathematical advancement. While there may be no general agreement among the mathematical community about answers to certain philosophical questions involving the foundations of mathematics, there is no doubt that reflecting on foundations has led to interesting and important mathematics. (Received September 09, 2012)

1086-L5-874 **Mate Szabo***, mszabo@andrew.cmu.edu. *Kalmár's Argument Against the Plausibility of Church's Thesis.*

In his famous paper, *An Unsolvable Problem of Elementary Number Theory*, Alonzo Church (1936) identified the intuitive notion of *effective calculability* with the mathematically precise notion of *recursiveness*. This proposal, known as Church's Thesis, has been widely accepted. Only a few papers have been written against it. One of these is László Kalmár's *An Argument Against the Plausibility of Church's Thesis* from 1959, which claims that there may be effectively calculable functions which are not recursive. The aim of this paper is to present Kalmár's argument in detail, and to give an insight into Kalmár's general views on the foundations of mathematics. In order to do this, first I will survey Kalmár's papers on the philosophy of mathematics, *The Development of Mathematical Rigor from Intuition to Axiomatic Method* (1942) and *Foundations of Mathematics – Whither Now?* (1967). Then I will present his argument against Church's Thesis in detail. After that, I will attempt to make his argument more appealing drawing on the core views he expresses in his other papers on the philosophy of mathematics. (Received September 14, 2012)

1086-L5-1597 **Daniel C. Slougher*** (dan.slougher@furman.edu), Department of Mathematics, Furman University, Greenville, SC 29613. *Philosophical and mathematical considerations of continua.* Preliminary report.

What is a continuum? How is one composed?

Are these mathematical or philosophical questions? Over the years, mathematicians have conceived of continua in various ways. For the most part, modern mathematics considers a linear continuum to be anything homeomorphic to the real line (the real numbers endowed with a certain topology). Is this progress, or just consensus around one of many possible conventions?

Philosophical considerations of the nature of continua go back to at least Zeno. Over the last 2500 or so years, philosophers have given careful thought to the consequences of differing hypotheses concerning the makeup of continua without ever reaching anything close to a consensus. Is this lack of progress?

This talk will provide a brief historical overview of how philosophers and mathematicians have thought about continua and then address the question of whether or not philosophers have anything to contribute to how mathematicians conceive of them. In particular, we will look at some criticisms which C. S. Peirce directed at the identification of linear continua with the real numbers. (Received September 23, 2012)

Preparing Elementary School Mathematics Specialists

1086-M1-480 **Cynthia Anhalt*** (canhalt@math.arizona.edu), Department of Mathematics, The University of Arizona, 617 N. Santa Rita Ave., Tucson, AZ 85721, and **Taliesin Sutton.** *Using the Intel Math Course to Train and Support K-8 Mathematics Specialists.* Preliminary report.

Intel Math curriculum is a popular means to create and further educate mathematics specialists in K-8 schools. This talk is based on our experiences teaching the Intel Math Course to over 200 K-8 teachers and administrators across 6 school districts in Southern Arizona. We will discuss our experiences in these workshops, focusing our attention on (1) how teachers interacted around the mathematics and (2) how the participants within each cohort supported one another's thinking about mathematics and mathematics pedagogy. The Intel Math course is a content-intensive professional development adapted from the curriculum developed by Kenneth Gross, Professor of Mathematics and Education at the University of Vermont. The course is 80 hours of professional development in mathematics co-instructed by a mathematician and a mathematics educator. Topics covered are integer arithmetic, the decimal number system, place value, rational number arithmetic, rates, linear equations, and functions. In addition to increasing teacher content knowledge, this course provided a space to support and facilitate a conversation about mathematical content and pedagogy among teachers, teacher leaders, and (in some cases) administration both within and across schools. (Received September 04, 2012)

1086-M1-589 **Gary A. Harris*** (gary.harris@ttu.edu), Department of Mathematics, Texas Tech University, Lubbock, TX 79409. *Upper division math courses designed specifically for the undergraduate per-service middle school mathematics specialists.*

We report on the results obtained in the first four years of a five year National Science Foundation Math/Science Partnership project. These results include significant increases in the conceptual math knowledge (CMK) and math knowledge for teaching (MKT) of the participating middle school math teachers. We then describe our plans to use knowledge gained from this project to transform the undergraduate middle school pre-service mathematics teacher program at our large state university. The transformation will involve creating and implementing six upper division mathematics courses designed to meet the specific needs of the future middle school mathematics specialists. The six courses will cover topics from Algebra, Geometry, Probability and Statistics, History of Mathematics, Mathematical Modeling, Mathematical Technology, respectively. All materials will be original creations of mathematicians in the Department of Mathematics and Statistics at our university. The content of each text will be influenced by the forthcoming Conference Board of Mathematical Sciences Mathematical Education of Teachers II (CBMS-METII) document, and the philosophy inspired by L.P. Ma's observations that these teachers of mathematics need have a "profound understanding of fundamental mathematics". (Received September 07, 2012)

1086-M1-719 **Carol E. Seaman*** (ceseaman@uncg.edu), PO Box 26170, Greensboro, NC 27602-6170, and **David K. Pugalee** (david.pugalee@uncc.edu), 9221 Ravenwing Dr., Charlotte, NC 28262. *North Carolina Elementary Mathematics Add-On License Program.* Preliminary report.

The North Carolina Elementary Mathematics Add-On License (NC EMAoL) program focuses on the mathematical knowledge needed for successfully teaching mathematics at the elementary level (grades K through 5). Currently, elementary school teachers are considered generalists because the majority complete only one or two mathematics courses as part of their teacher preparation programs; therefore, they need additional coursework to build an essential understanding of mathematics, the process of learning mathematics, and children's mathematical thinking, thus giving them the knowledge and skills to be strong mathematics teachers. The NC EMAoL program includes six graduate courses; each focused on a high-leverage teaching practice (HLTP), a primary area of mathematical content that provides the context for exemplifying the HLTP, and a secondary area of mathematics that provides the context for demonstrating the transfer of the HLTP to other content strands. Content includes number systems and operations, number theory and rational numbers, measurement, algebraic

reasoning, spatial orientation and visualization, and mathematical modeling. Each course also identifies the profound understandings of fundamental mathematics teachers will develop and demonstrate through the program of study. (Received September 11, 2012)

- 1086-M1-731 **Jennifer E. Szydlik*** (szydlik@uwosh.edu), Math Department, UW Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54901. *Big Ideas in Mathematics: An Inquiry-Based Program to Prepare Elementary Math Specialists.*

During the past fifteen years, the University of Wisconsin Oshkosh has prepared more than 200 mathematics specialists for the elementary grades. Our program is designed to help pre-service teachers gain a deep understanding of elementary and middle school mathematics, its definitions, representations, and connections to the broader mathematical landscape; to reveal mathematics as the practice of making sense of patterns; to examine the mathematical thinking of children; and to develop mathematical habits of mind. We will provide an overview of the program, its inquiry-based courses, and some materials we have developed to support these students in doing mathematics. (Received September 11, 2012)

- 1086-M1-2009 **Priya Vinata Prasad*** (pvprasad@math.arizona.edu), 617 N. Santa Rita Ave., Tucson, AZ 85721. *Understanding Changes in Teaching Practice After Content-Based Professional Development.* Preliminary report.

How can researchers design professional development so that it has a profound and lasting effect on participating teachers? This study involves a group of middle-school teachers participating in a three-year masters program designed to develop their mathematical leadership. The aim of this research is to understand how teachers form connections between content presented in professional development and the content they teach in class. Currently, literature in professional development has not fully addressed how such courses affect teachers' actual instructional choices in the classroom. Each teacher took part in a semester-long course in algebra designed specifically for this professional development program and then participated in a task-based interview designed to probe her understanding of the algebraic concepts covered in the course. Then, teachers were observed in their classrooms as they taught similar algebraic concepts. Teachers' content knowledge was explored again in a post-observation interview. Preliminary findings imply that this program did change teachers' perspectives on algebra and their ideas about teaching algebra, based on teachers' self-reporting, and that these changes percolated to the classroom in a variety of ways. (Received September 24, 2012)

- 1086-M1-2808 **Kathleen D. Lopez*** (klopez@louisiana.edu), UL Lafayette Department of Mathematics, Box 4010, Lafayette, LA 70504, and **Peter A. Sheppard** (psheppard@louisiana.edu), **Patricia W. Beaulieu** (pwb0555@louisiana.edu) and **Christina Eubanks-Turner** (ceturner@louisiana.edu). *Elementary Mathematics Specialist Program at the University of Louisiana at Lafayette – Part I.* Preliminary report.

As part of a NSF Robert Noyce Master Teacher Fellowship grant, the University of Louisiana at Lafayette is instituting twenty-one hours of coursework that is required for the newly created Louisiana Elementary Mathematics Specialist Certification. This presentation focuses the development of the courses, on the Number Theory & Operations and Geometry & Measurement content courses, and on the Mathematical Pedagogical Content course. (Received September 25, 2012)

- 1086-M1-2817 **Patricia W. Beaulieu*** (pwb0555@louisiana.edu), UL Lafayette Department of Mathematics, Box 4010, Lafayette, LA 70504, and **Peter A. Sheppard** (psheppard@louisiana.edu), **Christina Eubanks-Turner** (ceturner@louisiana.edu) and **Kathleen D. Lopez** (klopez@louisiana.edu). *Elementary Mathematics Specialist Program at the University of Louisiana at Lafayette – Part II.* Preliminary report.

As part of a NSF Robert Noyce Master Teacher Fellowship grant, the University of Louisiana at Lafayette is instituting twenty-one hours of coursework that is required for the newly created Louisiana Elementary Mathematics Specialist Certification. This presentation focuses on the Algebra & Functions and Statistics content courses, on the Leadership course, and on the Practicum. Additional ideas for enhancing teacher knowledge will be discussed. (Received September 25, 2012)

- 1086-M1-2949 **Rebecca Ortiz***, rebecca.ortiz@ttu.edu, and **Carol Williams** and **Magdalena Pando**, magdalena.pando@ttu.edu. *Filling in the Gaps: Increasing Content Knowledge and Pedagogy of Elementary Teachers of Mathematics.* Preliminary report.

This presentation will discuss the new program designed for in-service elementary teachers at Texas Tech University entitled Proyecto English Learner Science and Mathematics Education, Proyecto El SMEd. This program,

developed in collaboration among departments at the university level as well as two local school districts, focuses on developing the mathematics and science knowledge and instructional practices to support all learners. Proyecto EL SMEd targets three domains of effective teachers and teaching: content knowledge, teaching and learning dispositions, as well as pedagogical skills. These elements are: (a) a high association between student outcomes and teachers' skills and (b) the impact of teachers' skills on student skills is mediated by teacher knowledge and dispositions. Thus, Proyecto EL SMEd features include: engaging teachers in complex problem solving in mathematics and science; collaborative partnerships with consortium school districts in a comprehensive approach to teacher training; the integration of recent strategies in developing ELs' mathematics and science academic literacy; and providing teachers with opportunities to critically examine their beliefs about teaching and learning mathematics and science content. (Received September 26, 2012)

Projects, Demonstrations, and Activities that Engage Liberal Arts Mathematics Students

1086-M5-61 **Gizem Karaali*** (gizem.karaali@pomona.edu), Department of Mathematics, Pomona College, 610 North College Avenue, Claremont, CA 91711. *A Humanistic Reading Component for an Introduction to Proofs Course.*

I use a reading component focused on the nature of mathematical proof in my MATH 101: Introduction to Analysis course, which is a "transition to upper division math" course that emphasizes writing proofs (basically, it is a writing workshop, math-department style). In this presentation I will share the readings, my reasons behind using them, and what I think my students get out of this experience. Some evidence will be provided, supporting my contention that student learning benefits from this exercise. (Received June 25, 2012)

1086-M5-538 **Eric B. Kahn***, ekahn@bloomu.edu. *Developing Voting Systems on the First Day: an IBL Approach.*

The character of a mathematics for liberal arts course makes it a natural place to incorporate active learning experiences throughout the semester. One obstacle that some professors feel must initially be overcome to make such experiences meaningful, is developing some minimum level of material first through lecture prior to any activity. However using their own life experiences as a substitute for lecture, students already have substantial background knowledge to develop and discuss meaningful mathematics that is new to them on the first day. The classroom activity presented is designed for such a first day experience and focuses on the inevitably varying students' interpretations of fairness when making a group decision and leads smoothly into a discussion of voting systems. We will discuss the actual activity itself, the common achievements and missteps of students when presenting their work on the first day, and how the activity helps define the expectations of student involvement throughout the semester. (Received September 06, 2012)

1086-M5-575 **Morteza Shafii-Mousavi*** (mshafii@iusb.edu), Indiana University South Bend, 1700 Mishawaka Ave, P O Box 7111, South Bend, IN 46634, and **Paul Kochanowski**, Indiana University South Bend, PO Box 7111, South Bend, IN 46634. *Service-Learning Projects and Activities that Engage Liberal Arts Mathematics Students: Implementation and Assessments.*

We will present how the use of service-learning projects helps students in liberal arts courses gain greater understanding of math, as well as to improve their understanding of math language, ability to communicate solutions, and write recommendations to clients. Student teams complete client driven projects which emphasize discrete math. Given a project, a team meets its client organization; defines the problem; formulates the model; and writes research issues. A team focuses on data needs, statistical measures, and technological skills necessary to solve its problem. They write journals and communicate their ideas. In the classroom, students learn core math concepts. Finally, teams write reports and make presentations. We use rubrics to evaluate students' learning consisting of exams, projects, reports, presentations, and recording course work in student portfolios. We will discuss a completed project; the learning environment; how the activities were conducted and evaluated; how projects fit into the course; the technology; the students' reactions, and the effect of the project on the students' attitudes. We will provide handouts including rubrics used to assess student learning and the list of completed projects pursued in our interdisciplinary course Mathematics in Action. (Received September 07, 2012)

- 1086-M5-716 **Ksenija Simic-Muller*** (simicmka@plu.edu), Pacific Lutheran University Math Department, 1010 122nd St S, Tacoma, WA 98447. *An open-ended project for a liberal arts mathematics course.*

This paper describes the final project assigned in a liberal arts mathematics course taught during an intensive four-week January term. Most students enrolled in the class majored in the arts or humanities and expressed a strong disliking for mathematics. The focus of the class was quantitative literacy, in particular as it pertains to social justice issues. For the final project, the students were allowed to pick any topic they were interested in (a list of suggested topics was also provided) to investigate using mathematics. Once they picked a topic, students submitted an outline of the project a week before it was due, and a draft a day before it was due. The instructor offered ample feedback to both. Instructions given for the project were deliberately minimal, to allow the students to be creative and gain a better understanding of how mathematical arguments are created. Though initially uncomfortable with the lack of strict guidelines, almost all students produced strong papers and gave engaging presentations. They showed ownership of the the material, especially in the cases when they picked topics they felt passionate about, like the war on drugs or appropriation of American Indian lands. The project also helped improve the students' attitude toward mathematics. (Received September 11, 2012)

- 1086-M5-877 **Andrea N Young***, younga@ripon.edu. *Little Fractal on the Prairie: a study of fractal dimension.*

This talk will discuss a project completed by students in a first year seminar course (Math 175: The Shape of the Universe) at Ripon College. Students visited Ripon's Ceresco Prairie Conservancy, which has 130 acres of native prairie, oak savanna and wetland habitat. They photographed natural fractals and used various techniques to approximate the fractal dimensions. This project served as an introduction to mathematical modeling and got students thinking deeply about the concept of dimension. (Received September 14, 2012)

- 1086-M5-903 **Jacci White*** (jacci.white@saintleo.edu), Saint Leo University, Department of Mathematics and Sciences, MC 2188, Saint Leo, FL 33574, and **Scott B. White** (scott.white@saintleo.edu), Saint Leo University, Department of Mathematics and Sciences, MC 2188, Saint Leo, FL 33574. *A spectrum of Values, Critical Thinking, Writing, and Social Justice activities used to engage students and to assist adjuncts in mathematics.* Preliminary report.

This talk will share highlights from a collection of interactive student activities that include examples from years of university initiatives including "values and critical thinking for effective problem solving", "writing across the curriculum", "in the news", and "social justice across the curriculum". Not only do these activities give adjuncts a wide variety of options to choose from without needing training for each new initiative, but they also help students to make connections between classes and become more aware of the mathematics around them. Some of the mathematical topics include problem solving, measurement, geometry, probability and statistics, algebra, and financial mathematics. Many activities will be referenced and a few student results will be shared. We have found this collection to be a nice complement to the Pearson online course content on our campus. (Received September 15, 2012)

- 1086-M5-1256 **James C. Price*** (j.c.price@uafs.edu), UAFS, Department of Mathematics, 5210 Grand Avenue, P.O. Box 3649, Fort Smith, AR 72913-3649. *Bringing Mathematics to Life through Dialogue Based Activities and Manipulatives.*

Recently, I took over teaching college mathematics at my institution. While talking to my colleagues and consulting various reports on best practices in teaching such a course, I repeatedly came across the word activity. To be honest, I was somewhat perplexed at the time by what an activity in mathematics should be, but I was determined to try to incorporate it into my class. The result of these efforts was a series of dialogue based activities that use manipulatives and inquiry based learning to engage liberal arts students in mathematics. In this talk, I will present one of these activities, which is a dialogue between a Ludwig, Amadeus, and Johann entitled, The Music of Optimization. In it, a student discovers how music and optimization can be related, and how mathematics can be used to bring a problem to life. (Received September 20, 2012)

- 1086-M5-1391 **Rachel R. Roe-Dale*** (rroedale@skidmore.edu), 815 North Broadway, Saratoga Springs, NY 12866. *A Strange Attractor in the Kitchen.*

First year seminars at Skidmore are designed to be multi-disciplinary. My first year seminar, "The Dynamics of Chaos," discussed many topics related to chaos theory and its development. In our discussion of strange attractors, we considered the pastry map as an example. This talk outlines one class activity where students prepared croissants or other puff pastry dough and examined the mathematics of the stretching and folding structure of this strange attractor. (Received September 21, 2012)

1086-M5-1395 **Erin E. Bancroft*** (eebancroft@gcc.edu). *The Future of Voting: Engaging students through designing voting systems.*

Voting theory is often a component of liberal arts mathematics courses due to its accessibility and its relevance to the lives of students. It also provides an ideal context for student participation in an important mathematical process: expanding upon existing results to develop new ideas. In this talk, I will discuss a project which engages students in this process by having them create, test, and evaluate their own voting system, using standard voting methods as a starting point. (Received September 21, 2012)

1086-M5-1603 **Jerome L. Caldwell*** (jerome.caldwell@uwrf.edu). *Liberal Arts Mathematics: Do It Yourself with SNAP – Simulation, Random Walks.*

Since 2010 Liberal Arts students at U. Wisc.-River Falls have created mathematical objects in an environment designed to increase their appreciation of and comfort with mathematics. The objects, built with guidance from the instructor, include queuing simulation models, random walks and function generators.

A challenge in this approach is providing a construction environment that avoids syntactical and formatting complexity. This is met by using the freeware program SNAP, aka Build Your Own Blocks, developed at the University of California, Berkeley as an extension of MIT's SCRATCH.

While we spend most of the course in this manner, an instructor who wished could employ one or more of the activities after spending a class session or two introducing the environment.

The paper discusses the following two activities. The presentation allows time for at least the first one.

1. Simulation – we build a model to simulate customers queuing for service. The students assemble the blocks (commands) to make the model and then experiment with adding and removing servers to improve customer satisfaction while avoiding excessive cost.

2. Random Walks – this model graphically represents a random walk. We introduce various invisible fences defined by relations in x and y . (Received September 23, 2012)

1086-M5-1824 **Andrew-David Bjork*** (abjork@sienaheights.edu), 1247 E. Siena Heights Dr., Adrian, MI 49221. *A final project in a mathematics of games class: create your own new game!*

Almost every game that has ever been played by a human being has an underlying mathematical structure. Every student that I have ever taught has played games. Some they find fun, others boring. Some start out as fun, but fail to keep the interest of the player. Through a mathematics of games course, my students learn to appreciate the mathematical underpinnings of a game, manipulate mathematical models to learn to play better, and eventually, they begin to understand what makes a game fun for them. As a capstone for the course, my students get to design an original game from scratch. I will present this group project, complete with instructions, a grading rubric, and some final completed projects. (Received September 24, 2012)

1086-M5-1896 **Patricia Baggett*** (baggett@nmsu.edu), Dept of Mathematical Sciences, NMSU, MSC 3MB PO Box 30001, PO Box 30001, Las Cruces, NM 88003-8001, and **Andrzej Ehrenfeucht** (andrzej.ehrenfeucht@colorado.edu), Computer Science Dept., Box 430, University of Colorado at Boulder, Boulder, CO 80309-0430. *Projects for liberal arts majors explaining the concept of limit in probability problems simulated on the TI-84 calculator.*

At New Mexico State University, Math Appreciation (Math 210) is taken by many non-major undergraduates. Sections have up to 150 students, and instructors are free to design their own content. In our section we give the students a sequence of hands-on and virtual (simulated on the TI-84 calculator) tasks. The goal of these activities is to explain (to students who did not take calculus) the theoretical distribution as a limit of distributions observed from samples. In the talk we will describe the tasks, show the simulations, and report the students' reactions and their understanding (measured by their answers to specific test questions). (Received September 24, 2012)

1086-M5-2021 **J. Christopher Tweddle*** (ct55@evansville.edu). *Is it logical? Exploring the validity of arguments.*

As a capstone activity for the unit on logic (the propositional calculus), students engage in an in-class activity to test the validity of arguments that they encounter in the wild. As opposed to the seemingly domesticated examples that appear in the text and fit nicely into their boxes, the students' examples often need to be massaged and interpreted (carefully, to not change the meaning) in order to submit to analysis. We will present some examples of student work, using one to carry out the activity in the session. We will also share some remarks on students' reaction to the activity. (Received September 24, 2012)

- 1086-M5-2364 **Brian P. Beaudrie*** (brian.beaudrie@nau.edu), 805 South Osborne Dr, P. O. Box 5717, Department of Mathematics and Statistics, Flagstaff, AZ 86011. *Using JobQuests as a Capstone Project for Statistics in a Liberal Arts Mathematics Course.*

This paper will present the web-based activity JobQuest, a project for a statistics section of a Liberal Arts Mathematics course. The scenario presented to the students is as follows: they are to imagine that they have graduated in the field of their choice (their major). They are given job offers in six different cities across the country. Using statistics and statistical reasoning, reviewing a wide variety of statistical information, they are to decide which of the six offers they will accept, then give a Power Point presentation defending their choice.

The Power Point must have at least seven different statistics to back up their choice. The statistics they use must be in comparison with the other five cities under consideration. They are also to present at least three of their statistics in graphic form, using the proper graph. The other statistics can be presented in tables, as bullet points, or simply in paragraph form.

The goals of this project are to give students a real-world scenario in which statistical thinking can be applied, and to allow them to make connections with the statistical concepts they have recently studied. Through this project, students go beyond 'book learning' of statistical topics and realize how statistics are used in everyday life. (Received September 25, 2012)

- 1086-M5-2685 **Helmut Knaust*** (hknaust@utep.edu), Department of Mathematical Sciences, The University of Texas at El Paso, El Paso, TX 79968. *A Plaidoyer for Boolean Algebra.*

An introductory proofs course is often the first course exclusively taken by mathematics majors: Students study logic and sets first, then learn various proof techniques, and finally are exposed to functions and other relations. What is missing? Students do not learn to reason based on an axiomatic system. Typically examples are instead drawn from number theory, assuming the students to be somewhat familiar with its concepts. We propose to include the topic of Boolean Algebra as an example of an axiomatic system from the very beginning of the course. On the one hand, sets and binary logic provide the two classical examples of Boolean Algebra, on the other hand the topic can be revisited throughout the course, e.g. when studying order relations and functions. As an illustration we will present a homework problem sequence to accompany a proofs course which leads from the statement of the axioms of a Boolean Algebra to the classification theorem for finite Boolean Algebras. (Received September 25, 2012)

- 1086-M5-2714 **Jacqueline Anderson Hall*** (hallja@longwood.edu), HS Box 72, Hampden-Sydney, VA 23943-0072. *Voting: The Intersection of Mathematics & Citizen Leadership.*

This talk will describe a module on voting developed for a liberal arts mathematics class. Included is a summary of the module, descriptions of activities and worksheets, student reaction and my evaluation.

Longwood University declares its mission to be the "preparation of citizen leaders." A primary privilege and responsibility of citizenship is exercising the right to vote. Voting is beautifully situated at the intersection of mathematics and citizen leadership. We see presidential elections where the popular and Electoral College votes are split. The UN Security Council has some member countries who have the power to kill a motion while other members do not. What is going on in these votes?

This fall, I have decided to add a section on voting, scheduled just before the presidential election. Students will examine various methods of voting (Electoral College, plurality, different methods of determining a run-off, weighted voting), while observing paradoxes that occur. What do we mean by fairness? Is it possible for voting to be fair? Of course, at this point, I do not know how the students will react to this module on voting; however, I expect it to be an engaging and useful exercise. (Received September 25, 2012)

- 1086-M5-2784 **Steve Hilbert*** (hilbert@ithaca.edu), Stephen Hilbert, 208 Northview Road West, Ithaca, NY 14850. *Using Popular Culture to introduce Mathematical Ideas.* Preliminary report.

One way to interest students in Mathematical ideas that they are not required to know is to relate these ideas to their everyday experience. I have used popular books and pop music as "hooks" to illustrate how math is everywhere. An example of a popular book is Malcolm Gladwell's Blink. There are several interesting examples of mathematical concepts such as tasting jam in the context of multi dimensional problems and sampling and correlation applied to students' evaluation of teachers. The difference between exponential growth and linear growth can be examined in the context of what the concept of a You Tube video "going viral" means. For example as of September 25, 2012 the "Gangnam Style" and "Call Me Maybe" videos both have been viewed about 270 million times on You Tube but Gangnam Style has grown exponentially while Call Me Maybe has grown linearly. (Received September 25, 2012)

- 1086-M5-2946 **Christopher S Shaw*** (cshaw@colum.edu), Dept of Science and Mathematics, Columbia College Chicago, Chicago, IL 60605. *Voting Alliances: Using Politics to Motivate Combinatorial Counting.*

Consider an abstract situation in which a committee of voting members must make a selection from among a list. If all members vote completely at random, there is a relatively small chance that a single person from the list will receive a majority in an initial vote. In practice, however, such a vote would be made more complex, and a selection more likely, if the voters were to form alliances in which they agree to vote for the same person. We discuss several real-world examples of this scenario, from politics to reality television, and explain the mathematical probabilities involved at a level appropriate for an elementary probability class. (Received September 26, 2012)

Research on the Teaching and Learning of Undergraduate Mathematics

- 1086-N1-42 **Daniel L McGee***, daniel.mcgee@upr.edu, PR. *A Study of Effective Application of Semiotic Registers in the Development of the Definite Integral in Multivariable Calculus.*

Tracing the path from a numerical Riemann sum approximating the area under a curve to a definite integral representing the precise area in various texts and online presentations, we found three semiotic registers that are used: The geometric register, the numerical register and the symbolic register. The symbolic register had three treatment representations: An expanded sum, a sum in sigma notation and the definite integral. Reviewing the same texts, we found that in the presentation of double and triple integrals, not a single textbook continues to present the numerical register and the expanded sum treatment of the symbolic register. They are implied and the expectation appears to be that students no longer need them.

The omission of these registers is quite ubiquitous and correspondingly affects millions of students. With help from the NSF, materials that present the missing numerical register and the expanded sum treatment of the symbolic register throughout topics associated with double and triple integrals have been created. This paper presents the results of a clinical study on the improvement of student comprehension of multivariable integral topics when the numerical register are included. (Received June 15, 2012)

- 1086-N1-517 **Minsu Kim*** (mkim@gsc.edu), Gainesville State College, Post Office Box 1358, Gainesville, GA 30503. *The effect of preview video lectures using Smart Board, Camtasia Studios, and Podcasting on mathematical achievement and mathematics self-efficacy.* Preliminary report.

Mathematics instructors at colleges or universities have developed pedagogical approaches and methods both inside and outside the classroom through streaming video and podcasting because nowadays students are able to access the Internet everywhere using computers, iPhones, iPods, or smartphones. In addition, streaming video in higher education significantly influences students' achievements. The purpose of this study is to examine the effectiveness of preview video lectures about 5 minutes in length for each lecture using Smart Board, Camtasia Studios, and Podcasting in terms of mathematical achievement and mathematics self-efficacy in developmental mathematics and college algebra courses at a college. Data from approximately 180 students in six sections have been collected for two semesters through a classroom observation checklist of classwork, a questionnaire, the Mathematics Self-Efficacy Scales (MSES), a first exam, a final exam, and the COMPASS test. The results of this study will have implications for faculty and online system developers of textbooks and contribute to pedagogical approaches outside the classroom in mathematics education. (Received September 05, 2012)

- 1086-N1-555 **Elise Lockwood*** (elise314@gmail.com), **Estrella Johnson** (emjohns@pdx.edu) and **Sean Larsen** (slarsen@pdx.edu). *Developing Instructor Support Materials for an Inquiry-Oriented Curriculum.*

In recent years, reform-oriented mathematics curricula have become increasingly prevalent, gaining attention among policy-makers and enjoying, in some cases, widespread implementation. The process of scaling up such curricula to serve a wider audience is a significant challenge but is necessary if such innovations are to have a real impact on STEM education. In our Teaching Abstract Algebra for Understanding project, we sought to scale up a group theory curriculum that was developed through a series of design experiments and refined through several iterations of classroom trials. This process of scaling up motivated us to design Instructor Support Materials (ISMs) to support teachers in successfully implementing the curriculum. These ISMs have taken the form of an interactive website that provides instructors with a number of resources to help teachers implement

the curriculum effectively and faithfully. In this presentation, we describe the process of designing our ISMs, discussing relevant literature, design-based research methods, and examples from the research phases of our work, all of which contributed to the design of the ISMs. Our findings provide a resource for other researchers who seek to develop similar support materials. (Received September 06, 2012)

1086-N1-676 **Jessica Ellis*** (ellis3@rohan.sdsu.edu) and **Chris Rasmussen**. *Students' Differing Experiences in Calculus I*.

The number of students completing degrees in STEM continues to fall short of the demand for workers in these fields and hence is a national problem of great importance. Not only are too few students pursuing STEM fields, but also many who originally intend to pursue these fields leave after their experiences in introductory STEM courses. Based on data gathered in a national survey, we present an analysis of 5381 STEM intending students enrolled in introductory Calculus in Fall 2010, over 12% of whom switched out of a STEM trajectory after their experience in Calculus I. When asked why these students no longer intended to continue taking Calculus (an indicator of continuing their pursuit of a STEM major), 31.4% cited their negative experience in Calculus I as a contributing factor. In order to better understand the nature of students' classroom experience in Calculus I, we analyze student and their instructor survey responses on various aspects of their classroom experience in Calculus I (e.g. time spent lecturing, working in small groups, using technology, etc.). The analysis focuses on how students' perceptions of their Calculus I instruction relate to their persistence in Calculus, using the instructor's description of the class as basis for this comparison. (Received September 10, 2012)

1086-N1-996 **Hortensia Soto-Johnson*** (hortensia.soto@unco.edu), Ross Hall 2240C, Math Dept., Greeley, CO 80639, and **Gulden Karakok** and **Stephenie Anderson**. *In-Service Secondary Teachers' Conceptualization of Complex Numbers*.

This study explores three in-service secondary teachers' conceptualization of different forms (Cartesian, polar, and exponential) of a complex number z . We used Sfard's (1991) dual conceptualization framework to document the representations (points, vectors, ordered pairs, etc.) used by the teachers in response to tasks involving different forms. These representations allowed us to determine whether a participant possessed an operational or structural conceptualization of a given form. Our results suggest that the teachers possessed an operational conception of the Cartesian form and exponential form. On the other hand, two teachers showed evidence of a structural conception of the Cartesian form – thus, indicating dual conceptualization of the Cartesian form. Our data seem to suggest that the courses one teaches influences one's conceptualization of complex numbers. Given the recommendations put forth by the National Council of Teachers of Mathematics, the Common Core State Standards Initiative, and the Mathematics Teacher Education 2, we offer suggestions for developing a dual conceptualization of complex numbers as part of teacher training and professional development programs. (Received September 17, 2012)

1086-N1-1163 **Megan Wawro*** (mwawro@vt.edu), 460 McBryde Hall (0123), Blacksburg, VA 24061. *Reasoning About Solutions in Linear Algebra: The Case of Abraham and the Invertible Matrix Theorem*.

This study analyzes how one student, Abraham, reasoned about solutions to $Ax = 0$ and $Ax = b$ (for matrices A and vectors x , b , and 0), and how he reasoned about solutions to justify how concept statements in the Invertible Matrix Theorem (IMT) are related. This case study, rather than focusing on student difficulties in undergraduate mathematics, serves as a compelling example of the productive and powerful reasoning that is possible as students make sense of complex mathematics. Data sources were video and transcript from whole class discussion, small group work, and individual interviews. The overarching analytical structure was influenced by genetic analysis (Saxe, 2002), and Toulmin's Model of Argumentation (1969) was employed to analyze the structure of arguments both in isolation (microgenesis) and over time (ontogenesis). Results focus on Abraham's reasoning about how solutions to $Ax = 0$ and $Ax = b$ are related, on his reasoning with solutions to justify claims about other concepts in the IMT, and on how his flexibility with using and interpreting various symbolic representations of the two matrix equations may have facilitated his success in reasoning about and reasoning with solutions. (Received September 19, 2012)

1086-N1-1214 **Mary D Shepherd*** (msheprd@nwmissouri.edu), 9112 County Rd 62, Savannah, MO 64485. *Mathematicians Reading Mathematics—A View of the Experts*.

As students progress through the college mathematics curriculum, enter graduate school and eventually become practicing mathematicians, reading mathematics textbooks and journal articles appears to come easier and these readers appear to gain quite a bit from reading mathematics. This study was designed to help us begin to understand how more advanced readers of mathematics read for understanding compared to first year

undergraduate students. Three faculty members and three graduate students participated in this study and read from a first year graduate textbook in an area of mathematics unfamiliar to each of them. These observed reading strategies of more expert readers are compared to observed reading strategies of first-year undergraduate students. The reading methods of the faculty level mathematicians were all quite similar and were markedly different from all the students the researcher has encountered so far, including the more advanced students in this study. A proposed Mathematics Reading Framework and some teaching recommendations are given based on this study and years of observations of first-year undergraduate students reading their mathematics textbooks. (Received September 20, 2012)

1086-N1-1249 **Eric D Weber*** (eric.weber@oregonstate.edu), 103 SW Memorial Pl, Weniger Hall 233, Corvallis, OR 97333. *Two Students' Negotiation of Constructing Surfaces in Space.*

This talk describes two calculus students' ways of thinking about the construction of surfaces in space. There is a great deal of literature that focuses on student thinking about functions, but few studies explore the transitions students make as they begin thinking about functions of two-variables. This transition was the focus of the study. As such, these students participated in a teaching experiment focused on student thinking about two-variable functions and directional derivatives. This talk focuses on two major ideas drawn from the study. First, I describe the development of shape thinking, a new construct used to describe students' association of formulas and graphs. Second, I characterize how the students' interactions and discussions about generalizing from one to two variable functions influenced each of their ways of thinking. I conclude by discussing the implications for researchers and practitioners. (Received September 20, 2012)

1086-N1-1378 **Spencer Bagley*** (sbagley@ucsd.edu) and **Jeff Rabin**. *Computational thinking in linear algebra.*

In this work, we examine students' ways of thinking when presented with a novel linear algebra problem. We have hypothesized that in order to succeed in linear algebra, students must employ and coordinate three ways of thinking, which we call computational, abstract, and geometric. This study examines the solution strategies students employed to solve the problem, the variety of productive and reflective ways in which the computational way of thinking is used by honors undergraduate linear algebra students, and the ways in which they coordinate the computational mode of thinking with other modes. (Received September 21, 2012)

1086-N1-1420 **Michael A. Tallman*** (michael.tallman@asu.edu) and **Marilyn P. Carlson** (marilyn.carlson@asu.edu). *A Characterization of the Cognitive Demand of Calculus I Final Exams in U.S. Colleges and Universities.*

The final exam in a mathematics course is one source of information about the nature and level of student learning that is expected in the course. In this study, a three-dimensional framework was developed to analyze 150 post-secondary calculus I final exams from U.S. colleges and universities in an effort to determine the skills and understandings that are currently being emphasized in college calculus. Results indicate that Calculus I final exams generally require low levels of cognitive demand, seldom contain problems stated in a real-world context, rarely elicit explanation, and do not require students to demonstrate or apply their understanding of the course's central ideas. Data from a survey that investigated instructors' beliefs about teaching, the role of exams and homework in learning, etc. was completed by the same instructors and was used to investigate instructor beliefs that correlate with exams that are more and less conceptual in their focus. We found that there is a misalignment between the nature of calculus final exams and instructors' perceptions of their exams relative to the extent to which students are asked to explain their thinking and the proportion of exam items that focus on skills and methods for carrying out computations. (Received September 21, 2012)

1086-N1-1430 **Michelle R DeDeo*** (mdedeo@unf.edu). *Over A Decade of Improving Pass Rates in Gateway Mathematics Courses using Interactive Software.*

In October 2009, ENLACE Florida, a network of eight state universities promoting college-readiness, access, and success for underrepresented students in Florida, published an in-depth policy brief evaluating successful strategies in Gateway classes such as College Algebra and Finite Mathematics. Its results supported the findings in my paper entitled "Improving Pass Rates in Mathematics using Interactive Software" which gave a positive assessment of the use of software in the teaching of College Algebra.

Both papers forwarded the idea that interactive mathematics software promotes increased retention and success for students in College Algebra courses and that those students were engaged in learning both at school and at home.

Not only have these findings been confirmed over the past decade, one system in particular proved to be successful, flexible and a better fit than the others tested. This talk updates those results and discusses the continued success.

We evaluate over a decade's worth of study, present student and instructor feedback, and compare how well the students performed in sections that utilized software versus: (1) those instructors who made use of the system optional, (2) those who used another system, and (3) those that did not use any system at all. (Received September 21, 2012)

- 1086-N1-1465 **Aviva Halani*** (aviva.halani@asu.com), AZ. *Students' Ways of Thinking about Solution Sets Envisioned as Unions of Subsets and Their Relation to Over Counting in Combinatorics.*

This presentation aims to address students' ways of thinking about the set of elements being counted in enumerative combinatorics problems, known as the solution set. In particular, it will identify ways of thinking about solution sets students envisioned as the union of subsets and their relation to over counting the size of solution sets. Three undergraduate students with no formal experience with combinatorics participated in a teaching experiment in spring 2012, conducted as two phases. This presentation focuses on two particular ways of student thinking which emerged from the data analysis: Addition and Union. Addition involves thinking locally first and counting the size of a subset of the solution set before adding on the size of its supposed complement. Students engaging in Union think globally first and view the solution set as the union of subsets, which they may believe to be disjoint. If the subsets are not disjoint, the students over count the size of the solution set. Through instructional interventions involving Venn diagrams, the student in the second phase was successful in attending to the intersection of the subsets and adjusting his solutions. We will discuss how an instructor might build upon students' thinking to help them recognize and avoid over counting. (Received September 22, 2012)

- 1086-N1-1549 **Rebecca-Anne Dibbs*** (rebecca.dibbs@unco.edu), School of Mathematical Sciences, University of Northern Colorado, Greeley, CO 80634, and **Michael C Oehrtman**. *The effects of formative assessment on students' Zone of Proximal Development in introductory calculus.* Preliminary report.

One of the challenges of teaching introductory calculus is the large variance in student backgrounds. Formative assessment can be used to target which students need help, but little is known about why formative assessment is effective with adult learners. The purpose of this qualitative study was to investigate which functions of formative assessment help instructors to provide the scaffolding needed to help students in an introductory calculus course progress through their Zones of Proximal Development during the weekly group labs. These scaffolding opportunities allowed a rapid and rich acquisition of the concepts of limits, derivatives, and definite integrals within the Approximation Framework. By providing students a low-stakes opportunity to demonstrate their current understanding, students were able to evaluate their progress and ask further questions after the activity was completed; this information was used to plan the discussion in the next class period. This discussion provided the scaffolding students needed to progress through the activities as well as providing peripheral participation opportunities for students who would not ordinarily ask questions during class. (Received September 23, 2012)

- 1086-N1-1970 **Estrella Johnson***, emjohns@pdx.edu, and **John Caughman, Julie Fredericks and Lee Gibson**. *Implementing Inquiry-Oriented Curriculum: From the Mathematicians' Perspective.*

As part of an effort to scale up an instructional innovation in abstract algebra, several mathematicians have implemented an inquiry-oriented, group theory curriculum. Three of those mathematicians (co-authors here) also participated in iterative rounds of interviews designed to document and investigate their experiences as they worked to implement this curriculum. Analyses of these interviews uncovered three themes that were important to these mathematicians: coverage, goals for student learning, and the role of the teacher. Here we will present and discuss each teacher's views relative to these three themes. We will draw on interview data, classroom data, and first person commentaries in order to articulate each teacher's goals, emphases, and bases for decision-making. (Received September 24, 2012)

- 1086-N1-1978 **Brian Arthur Christopher*** (brian.christopher@unco.edu), 501 20th Street, Campus Box 122, Greeley, CO 80639. *The Connection between Calibration Levels and Students' Mathematical Proficiency.*

In this presentation, I will share the results of a study that examined the relationship between calibration and students' mathematical proficiency. Calibration is defined to be the measure of a person's perceived performance on a task compared to his or her actual performance on that task. The literature on calibration has quantitatively

linked calibration's effect on student achievement. However, there has not been an attempt to connect calibration to students' mathematical proficiency. In this study, mathematical proficiency was defined using the five strands of mathematical proficiency in Adding it up: Helping Children Learn Mathematics. Each participant filled out surveys before and after an assessment, which were used with their actual scores to determine their calibration score and grouping. Then their assessments were coded for mathematical proficiency. Comparing the students' calibration to their mathematical proficiency and achievement, I found that the study matched findings within the literature with higher calibrated students performing better on exams; in addition, to them being more mathematically proficient. These results suggest that by helping students become more calibrated, instructors and researchers may help students succeed in the mathematics classroom. (Received September 24, 2012)

1086-N1-1998 **John Paul Cook***, jpcook@usao.edu. *The Emergence of Algebraic Structure: Students Come to Understand Zero-Divisors.*

Little is known about how students learn the basic ideas of ring theory. While the literature addressing student learning of group theory is certainly relevant, the concept of zero-divisor in particular is one for which group theory has no analog. In order to better understand how students come to understand zero-divisors, this talk will present results from a study that investigated how students can capitalize on their intuitive notions of solving equations to reinvent the definitions of ring, integral domain, and field. The emergence and progressive formalization of the concept of zero-divisor at various stages of the reinvention process will be detailed and discussed. (Received September 24, 2012)

1086-N1-2067 **Matthew Thomas*** (mthomas@math.arizona.edu) and **Guadalupe Lozano** (guada@math.arizona.edu). *Analyzing Conceptual Gains in Introductory Calculus with Interactively-Engaged Teaching Styles.*

Research in mathematics and physics education indicates that students in interactively engaged classrooms are more successful on tests of basic conceptual knowledge than students in traditional lecture-based classrooms. Despite this, undergraduate mathematics courses are dominated by lectures in which students take a passive role. While studies involving tools such as Peer Instruction and the Force Concept Inventory have encouraged changes in the ways introductory physics is taught, changes in mathematics instruction have not occurred to the same extent.

Using the recently developed Calculus Concept Inventory together with video and audiotape analysis of introductory Calculus classes, we investigate specific aspects of interactively-engaged teaching and determine which aspects of Interactively-Engaged teaching are most correlated with conceptual learning.

In this presentation, we will briefly describe the coding protocol that was developed for the 15 videos, using 5 instructors. We will also present results demonstrating the relationship between types of interactions occurring in the classroom and both conceptual and procedural learning, as measured by the Calculus Concept Inventory and course final exam. (Received September 24, 2012)

1086-N1-2071 **Sean P. Yee*** (syee@fullerton.edu), California State University, Fullerton, Department of Mathematics, 380A McCarthy Hall, Fullerton, CA 92834. *Improving undergraduate mathematics education using dynamic graphics embedded within WeBWork.* Preliminary report.

This presentation will demonstrate the preliminary results and data collected from collegiate calculus courses taught at Cleveland State University using customizable Adobe Flash Applets in tandem with WeBWork problems. These applets have multiple uses to scaffold students' understanding of conceptually rigorous topics such as limits in single variable and multivariable calculus. This is done using dynamic, motion-based applets embedded within the problems as an optional means of supporting conceptualization. Additionally, these applets give the student more freedom to explore problems by manipulating multiple variables, offering students a virtual learning experience. From a curriculum perspective, this software offers students a novel medium to develop a cognitively embodied understanding of calculus. The presentation will demonstrate examples of the applet as well as report on preliminary data from this NSF-funded study. (Received September 24, 2012)

1086-N1-2173 **Cameron O Byerley** (cameron.byerley@gmail.com), 6719 E Oak St, Scottsdale, AZ 85257, and **Neil Hatfield*** (njhatfie@asu.edu). *University Calculus Students' Meanings for Fraction and Quotient.*

The research reported here extends our earlier finding that high-performing Calculus students often had weak meanings for quotient and rate. Multiplicative meanings for quotient are critical for understanding derivatives and rates of change. In this study, seventeen math education majors completed a test on fractions and quotient.

From this group, one above-average Calculus student was selected to participate in a six-lesson teaching experiment. The major question investigated was “what constrains and affords the development of the productive meanings for quotient and fractions articulated by Thompson and Saldanha (2003)?” The student’s thinking was described using Steffe and Olive’s (2010) models of fractional knowledge. The report focuses on the student’s part-whole meaning for fractions and her difficulty assimilating instruction on partitive meanings for quotient. Her part-whole meaning for fractions led to the resilient belief that any partition of a length of size m must be into m , unit size pieces. She repeatedly practiced anticipating the result of partitioning length m into k equal pieces and began to develop an iterative fraction scheme. It was non-trivial to develop the basic meanings necessary to understand rate of change, even with a student who passed Calculus. (Received September 25, 2012)

1086-N1-2237 **Cameron Byerley*** (cameron.byerley@asu.edu), P. O. Box 871804, Tempe, AZ 85287-1804, and **Neil Hatfield, Marilyn Carlson and Patrick W Thompson.** *Assessing high school teachers’ Mathematical Meanings for Teaching secondary mathematics.* Preliminary report.

Research on Mathematical Knowledge for Teaching elementary mathematics (MKTem) blossomed in the 1980’s and 1990’s. Assessments of MKTem evolved naturally from this work, culminating in Hill and Ball’s assessments of teachers’ MKTem. Delineations of teachers’ Mathematical Knowledge for Teaching secondary mathematics (MKTsm) have been less focused, concentrating mostly on the teaching of lower algebra. This is due to the sophistication and interconnections of higher math concepts. Attempts to capture MKTsm must focus on mathematical meanings behind teachers’ instructional actions. We will report a study of secondary teachers’ mathematical meanings.

We focused on meanings that undergird the pre-calculus curriculum—variation, quantity, function, and representational equivalence. Thirty-six paper items were given to 141 teachers in four MSP summer workshops. The items were distributed across three forms—9 items common to each form and 9 items unique to each form. In addition, each teacher responded to three animated items. The animated items’ foci were (a) proportionality and functions, (b) functions, graphs, and equations, and (c) constant and average rate of change.

We will illustrate our method for discerning teachers’ meanings and convey preliminary findings. (Received September 25, 2012)

1086-N1-2326 **Sybilla Beckmann*** (sybilla@math.uga.edu), Department of Mathematics, 200 D. W. Brooks Drive, University of Georgia, Athens, GA 30602, and **Andrew Izsak, Erik Jacobson, Eun Jung and Eun Kyung Kang.** *How prospective grades 6 - 8 teachers use two definitions of ratio.* Preliminary report.

Although there is a substantial body of research on children’s thinking and learning of ratio and proportional relationships, much less is known about how teachers or prospective teachers think about this important domain. It is known to be difficult to decide whether a ratio relationship does or does not appropriately model a given situation. However, the literature has gaps concerning what ratio means. We describe two distinct ways to specify what it means for two quantities to be in the ratio A to B , a “variable numbers of fixed measurements” definition and a “fixed numbers of variable parts” definition. These two definitions fit with the Common Core State Standards for Mathematics and parallel two common definitions of division, which indicate what $A \div B$ means in terms of quantities, namely, “how many in each group?” or “how many groups?”. The literature also has gaps concerning how and whether definitions of ratio could be useful in understanding ratio as a measure of intensive quantities and in determining appropriateness of a ratio relationship to a situation. We describe some preliminary results on how prospective teachers use the definitions together with drawn models, especially double number lines and tape diagrams, to reason about ratio relationships. (Received September 25, 2012)

1086-N1-2710 **Maira Kathleen Devlin*** (maira.devlin@gmail.com), 1222 Kemper Drive, Warminster, PA 18974, and **Agnes Rash.** *Mathematics Anxiety and Performance: Finding the Source to Lead to the Cure.*

Mathematics anxiety is an issue associated with the development of mathematical skills in students. In this analysis, the authors examine literature on the background of math anxiety, the relationship between math anxiety and achievement, and proposed solutions for intervention to decrease math anxiety. We have designed a study that measures the effects of the pedagogical approach in a college level course, “The Whole Truth About Whole Numbers.” Through the course at Saint Joseph’s University, we observe the presence of mathematics anxiety, the attitudinal change of anxiety over the course of the semester, and the content knowledge change through a pretest/posttest design. Also, based on the recommendations found in the literature search on intervention, we created games that have been implemented into this course. (Received September 25, 2012)

- 1086-N1-2734 **Stacy M Musgrave*** (smusgrav@uga.edu), Department of Mathematics, Boyd GSRC, University of Georgia, Athens, GA 30602-7403, and **Kevin C Moore**. *Conventions and Mathematical Meaning—An Exploration Through Functions and Inverses*.

A central purpose of mathematical conventions is to aid in the communication of mathematical ideas within the mathematical community. In an exploratory study conducted via clinical interviews of pre-service secondary teachers and pre-calculus students at the undergraduate level, we investigated the role of mathematical conventions in their thinking about functions, including inverse relations. Compatible with previous research, the participants' function and inverse meanings relied heavily on the representation under consideration and the participants struggled to conceive commonalities across different representations (e.g. graphical, numerical, and equation-based). Additionally, the participants' function and inverse meanings inherently involved mathematical conventions. Because of this, the participants often characterized peer posed solutions as incorrect if these solutions did not conform to common mathematical conventions (e.g., input on the horizontal axis and output on the vertical axis). These results highlight that conventions can constrain individuals' mathematical meanings and quantitative reasoning, rather than having conventions serve a supporting role for consistent communication, in the event that conventions become inherent aspects of their thinking. (Received September 25, 2012)

- 1086-N1-2794 **Jungeun Park*** (jungeunpark124@gmail.com), 15 Orchard Rd., Newark, DE 19711, and **Jason Martin** (jasonm@uca.edu), 201 Donaghey Ave., Conway, AR 72035. *Role of Instructor Prompts in Reinvention of Sequence Convergence Definition*. Preliminary report.

Studies have shown that students have difficulty with the concept of limit, especially when reasoning about formal limit definitions. We conducted a five-day teaching experiment (TE) in a second semester calculus classroom in which students were asked to reinvent a formal sequence convergence definition. Classes were videotaped and students' written work was collected. Oehrtman, Swinyard, Martin, et al., (2011) detailed how pairs of students reinvented sequence convergence definitions but they did not consider the same instructional heuristic in the classroom. Analysis of our classroom data focused on the interaction between the instructor and a group of student participants. We explored the characteristics of this interaction by looking at instructor prompts and the TE students' subsequent group discussion through their use of key words and visuals in revising their definition. An interview with the instructor was conducted to investigate his intention of using specific prompts and his thinking about the TE group's choice of words and visuals. We found that the roles of the instructor were extended beyond those roles previously reported as roles for facilitators with pairs of students. In this talk we present these roles and the impact of these roles on the reinvention process. (Received September 25, 2012)

- 1086-N1-2848 **Benjamin Wescoatt*** (ben.wescoatt@gmail.com), Oklahoma State University, 401 MSCS, Stillwater, OK 74078. *Students' Idiosyncratic Usage of the Equal Sign While Verifying Trigonometric Identities*. Preliminary report.

This paper explores students' conceptions of verifying trigonometric identities. Despite providing opportunities for investigating many areas of student knowledge, students' conceptions involved in verifying trigonometric identities (VTI) have not been well-studied. To explore these conceptions, eight undergraduate trigonometry students were interviewed while engaged in VTI. The students were encouraged to think aloud as they solved the problems. Interview questions focused on understanding students' motivations for their problem solving decisions and actions. The transcripts of the interviews were analyzed using an open-coding method, and themes evolved. One theme pertained to students' idiosyncratic usage of the equal sign. This paper will provide examples from student interviews of their idiosyncratic usage and will discuss the meanings the usage has to each student. Instances of the equal sign being used as an organizational symbol were identified. Additionally, students used the equal sign to demonstrate tentative, temporal equality; successful verification of the identity transformed the tentative equality to equality. Some students constructed a visual cue to signal a successful verification by writing a reflexive equality as their final step. (Received September 25, 2012)

- 1086-N1-2862 **Hyunkyong Yoon*** (hyoon14@asu.edu), 1720 E. Broadway Road #1159, Tempe, AZ 85282. *What is pre-service understanding on the concept of vector?*

This study examined pre-service teachers' knowledge on the concept of vector. Literature reports that pre-service teachers struggle with making connection between a way that vector is introduced in school mathematics (directed line segments) and that in college mathematics (elements of a vector space). Eighty pre-service teachers preparing an exam for public secondary mathematics teachers in Korea participated in a survey. Hillel's theory about modes of description was employed to analyze their Mathematical Knowledge for Teaching about vectors regarding (1) Common Content Knowledge (CCK): To what degree do you think mathematical objects describe properly the concept of vector? and (2) Specialized Content Knowledge (SCK): How would you respond if your

students ask the concepts of vector, zero vector, and negative vector? Results show that pre-service teachers' CCK and SCK on vector were both leaning towards geometric objects. The pre-service teachers' CCK was also strongly related to their SCK that they use when they became teachers. It was apparent that their knowledge was closer to school mathematics rather than college mathematics. This presentation will discuss the implication of the study to design college mathematics courses for teachers. (Received September 26, 2012)

Scholarship of Teaching and Learning in Collegiate Mathematics

1086-N5-166 **Jerry C Obiekwe*** (accessx@uakron.edu), P. O. Box 411, Orrville, OH 44667.
Mathematical Word Problems: An Investigation of the Optimum Period of Teaching Word Problems in a College Algebra Course in Order to Maximize Learning Outcomes.

Mathematical word problems are perhaps the most challenging aspect of college algebra for most students. Several factors may be responsible for this dilemma. The cognitive complexity of word problems highlights the translation phase as the most difficulty because of the linguistics and the general knowledge requirement. In most college algebra text books, the topics are arranged in such a way that the word problems are dealt with in the first few weeks of the semester. The question is: does the textbook arrangement presents the best scenario for maximizing the learning of word problems if linguistics is assumed to be a bottleneck for students. This study examined the best time to teach word problems in order to produce the best results by comparing data between teaching word problems in the first few weeks of the semester, as arranged in the textbook, and the last week of the semester. The results and the implications to teaching and learning word problems will be discussed. (Received August 01, 2012)

1086-N5-649 **Donna Beers***, Department of Mathematics and Statistics, Simmons College, Boston, MA 02115. *Using the Equivalence Kernel of a Function to Strengthen the Teaching and Learning of One-to-One Functions and Equivalence Classes in Discrete Mathematics.*

This presentation will describe the revisions we made, in fall 2012, to a discrete mathematics course for mathematics majors in order to strengthen student understanding of one-to-one functions as well as equivalence classes. Our long run goal is to prepare students for the study of quotient structures in advanced courses such as modern algebra. Our approach was to introduce the concept of the equivalence kernel of a function. We will describe curricular enhancements we developed, including use of non-numerical functions arising from students' own classroom experience, plus visualizations of the equivalence classes corresponding to the equivalence kernel for each of the functions. We will report on the results of a pre- and post-survey that we developed and administered to assess the effectiveness of these enhancements. (Received September 10, 2012)

1086-N5-714 **Cynthia Y. Young*** (cynthia.young@ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816, and **Tammy M Muhs** (tammy.muhs@ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Improving Student Learning in Mathematics with Animations: WHYU vs. Khan Academy.* Preliminary report.

Animations are part of our students' lives. Learning experts classify animations as Demonstration Based Learning (DBL). Psychology and Mathematics faculty and graduate students collaborated to conduct a preliminary study in the Fall of 2012 at the University of Central Florida on the impact of DBL animations (WHYU and Khan Academy) on both student learning (conceptual and procedural) and student attitudes (self-efficacy and motivation to learn) in Intermediate Algebra courses. Preliminary results comparing the learning and affective gains in the three groups (control, WHYU and Khan) will be presented. (Received September 11, 2012)

1086-N5-1280 **Maria Shea Terrell*** (mst1@cornell.edu), Mathematics Department, Malott Hall, Cornell University, Ithaca, NY 14853, and **Lisa Schneider-Bentley**. *Applications and Confidence Inventories for Assessing Curricular Change in Introductory Engineering Mathematics Instruction.*

This paper reports on a project that grew from a collaborative effort by Engineering and Mathematics faculty at Cornell University to enhance engineering students' abilities to transfer and apply their knowledge of mathematics to solve problems in engineering contexts. It includes a summary of work to date to develop two instruments: one to assess first year engineering students' ability to apply mathematics they know, the Mathematics Applications Inventory (MAI), and the other to assess students' attitudes and self-efficacy regarding their ability to apply mathematics, the Engineering and Mathematics Perceptions Survey (EMPS). The paper will share what we

found when we used the instruments to assess changes in student learning over the course of a semester in which collaborative, applied, problem-solving workshops were integrated into Cornell's first semester engineering mathematics course. (Received September 21, 2012)

- 1086-N5-1498 **Laura J Schmidt*** (schmidtlaur@uwstout.edu), 231D Jarvis Hall Science Wing, MSCS Department, University of Wisconsin-Stout, Menomonie, WI 54751. *I can't believe my instructor expects me to do this: Methods for your classroom to promote clarity related to hopes and expectations.*

Findings will be presented from a 2010-12 multidisciplinary project studying the impact of improved communication of expectations on student motivation, metacognition, and the learning environment. The purpose was to identify gaps between student and instructor expectations, and to close those gaps through improved instructor-student communication. Additionally, researchers wanted to determine whether improved communication could aid in the identification of effective teaching practices and help to increase student motivation. Conclusions are based on student surveys, ongoing class dialogues, focus groups, and instructor observations. Future directions of the research will also be discussed. This project, conducted at the University of Wisconsin-Stout, is supported by University of Wisconsin-System Undergraduate Teaching and Learning Grants through OPID. (Received September 22, 2012)

- 1086-N5-1534 **Kirthi Premadasa*** (kirthi.premadasa@uwc.edu), 1006 Connie Road, Baraboo, WI 53913, and **Kavita Bhatia** (kavita.bhatia@uwc.edu), 2000 West 5th Street, Marshfield, WI 54449. *Algebra in real life: what do students choose ?*

This paper attempts to answer the question "When doing word problems, do College Algebra students prefer certain application contexts over others?" Two studies were done in two UW campuses to four sections of College Algebra students involving quadratic and exponential functions respectively. We gave problems in numerous application areas and asked students to select their top three preferences. The areas fell in to three categories: Category R (Problems on application areas to which students can readily relate to), Category I (Problems on application areas which contain a certain amount of intrigue or curiosity) and category U (Problems on more formal/distant application areas). We fit mixed-effects logistic regression models for the data from both studies separately taking "preference" as a binary response variable. Results show that students highly significantly preferred questions from I and R categories over questions from the U category. Even within the categories, certain questions were preferred more than the others. These conclusions will help teachers to select problems on application areas which either contain some intrigue or to which students can easily relate to when presenting motivating examples and assigning homework problems. (Received September 23, 2012)

- 1086-N5-1553 **Michael A. Posner*** (michael.posner@villanova.edu). *Engaging High School Math Students and Teachers Through a Proficiency-based Assessment and Reassessment of Learning Outcomes (PARLO) System.* Preliminary report.

The PARLO system (also referred to as standards-based grading, competency-based grading, or mastery learning) allows students who do not attain proficiency on a given learning outcome subsequent opportunities to learn the material and be reassessed. Previous studies at the K-16 levels have shown positive outcomes from using such a system.

The PARLO Study is an NSF-funded grant to conduct a randomized controlled trial of thirty-six secondary schools in Greater Philadelphia over four years. The main research questions are 1) does teachers' use of PARLO lead to increases in students' mathematics achievement, engagement, and attitudes? and 2) does PARLO foster changes in teacher's conceptions of learning. Results thus far show that the system has proven to be transformative to many teachers and students. Student attitudinal surveys and outcomes on tests are currently being reviewed and results will be presented at the meetings.

This potentially transformative method of assessment can lead to increased student learning, engagement and achievement. It also helps teachers understand that students can achieve when given the opportunity to do so. (Received September 23, 2012)

- 1086-N5-1844 **John C Nardo*** (jnardo@oglethorpe.edu), 4484 Peachtree Road, NE, Oglethorpe University, Division of Mathematics & Computer Science, Atlanta, GA 30319, and **J Lynn Gieger, Leah Zinner, Karen Schmeichel and Deborah Payne.** *Comparing Online and Traditional Textbook Homework in a College Algebra Class: A Second Generation SoTL Study.* Preliminary report.

This study explored the effectiveness of online homework vs. traditional textbook homework in a College Algebra course. This project extends an already presented SoTL project on homework in a Calculus course. In that study we found that, compared to written homework, when students completed online homework: (1) they did

homework more frequently during the week, (2) they made repeated attempts to master assignments, and (3) they had less office contact time with the professor but missed that contact. To build on this study, the current study used a control group/experimental group paradigm and matched courses as much as possible except for the homework modality.

We posit that the more frequent, regimented practice found in online homework should change the time distribution of homework over the week and increase the passage rate and test scores for the experimental group vs. the control group. However, the “answer focused” online homework system may lead to explanations which are less rich in the experimental group. Finally, we want to see whether the decrease in office contact in the previous study will replicate.

Results (completed 12/2012) will be used to inform future decisions about homework and to check academic progress in beginning mathematics. (Received September 24, 2012)

1086-N5-1932 **Brian Katz*** (briankatz@augustana.edu). *Teaching Mathematical Maturity through Axiomatic Geometry.*

Mathematical maturity includes the skills to communicate with precision, attend to detail, and interpret results through the epistemologies of the discipline. These themes silently suffuse our courses, but are we effecting any changes in the students? I will describe an inquiry-based course structured around an axiomatic development of Geometry, and I will analyze student products for evidence of changes in the level of mathematical maturity. The evidence will include a comparison of concept maps about mathematical truth from before and after the course as well as student reflection writings about the axiomatic method and their own development in proof construction and communication. (Received September 24, 2012)

1086-N5-2123 **Paul E Seeburger*** (pseeburger@monroecc.edu), Monroe Community College, 1000 E. Henrietta Rd., Rochester, NY 14623. *To What Extent Does Visualization Improve Conceptual Understanding in Multivariable Calculus?* Preliminary report.

This is a report on the data obtained to answer this question as part of a 4.5-year NSF-funded grant project called Dynamic Visualization Tools for Multivariable Calculus (DUE- CCLI #0736968). A multivariable calculus exploration applet named CalcPlot3D has been used by over 1000 students from all over the country to complete various concept exploration activities that include a pre-test, an exploration for which students use the applet to explore a concept visually and answer provided questions, and a post-test. The pre-test is intended to show what students know coming into the exploration, and the post-test was used to measure what they had gained from completing the exploration. Topics for the concept explorations were the Dot Product, the Cross Product, Velocity and Acceleration Vectors (in the context of motion along a plane or space curve), and Lagrange Multiplier Optimization. The data presented will include analysis of these pre- and post-test results, student comments on their own learning from questions at the end of these explorations, and data from various other sources. See <http://web.monroecc.edu/calcNSF/>. (Received September 24, 2012)

1086-N5-2151 **Mary Beisiegel*** (mary.beisiegel@oregonstate.edu), Department of Mathematics, 362 Kidder Hall, Corvallis, OR 97331. *Learning about teaching through experimentation and reflection.*

The Scholarship of Teaching and Learning identifies new avenues of research where instructors and professors of mathematics can look at their own teaching practice as an area worthy of investigation. During this session, I will illustrate how professors of mathematics can use experimentation and reflection to better understand their teaching practices, how to plan for lessons, and get students involved during class time. In particular, by combining three different perspectives of teaching and learning, which include (1) the “experiment” model defined by Hiebert, Morris and Glass (2003), (2) knowledge, orientations, and goals described by Schoenfeld (2011), and (3) the framework of the reflective practitioner explained by Chapman (2009), I will describe how professors of mathematics can, through lesson planning and course development, explore their own teach practice as a fruitful area of learning about and research into teaching. (Received September 24, 2012)

1086-N5-2264 **Allen Guest*** (aguest@clemson.edu), Department of Mathematical Sciences, Martin Hall, Clemson University, Clemson, SC 29631, and **Marilyn Reba, Calvin Williams, Roy Pargas and Ellen Breazel.** *Mathematics Partnering with Computer Science to Improve Calculus Instruction and Learning.*

Over the four years of an NSF-CCLI-II grant, we have implemented technology to increase interaction between instructors and at-risk STEM students in the teaching of calculus. We have created web-based software using digital ink for the submission of group activities and quizzes, and for an error-tagging project on exams. From a 2010 error-analysis on thousands of pages of Calculus I final exams, we created targeted online quizzes to alert

students early to common errors that typically escalate into course failure. Can we encourage at-risk students to remediate these mistakes while moving ahead in the course? For the second year, we have worked with faculty at Tri-County Community College in an online synchronous team-taught Calculus I course. We provide group activities for each class, as well as exams and the remediation quizzes. This pedagogical shift benefits students who transfer from Tri-County to Clemson. Prior to these joint efforts, there was a high failure rate (60%) when Tri-County students continued their Calculus studies at Clemson. We will share our performance statistics, surveys, and interview results. (Received September 25, 2012)

1086-N5-2466 **Aladar K Horvath*** (aladar@purdue.edu). *Students' Perceptions of Feedback and its Actual Impact on Students' Mathematical Modeling*. Preliminary report.

One benefit of mathematical modeling is that it allows for various suitable solutions. The challenge then is helping students understand what a "good" model is when there is not one right answer. Providing students with feedback on their mathematical model is one way to address this issue.

This study examined how students in a first-year engineering course perceived and responded to written feedback from Graduate Teaching Assistants (GTAs) on three Mathematical Model-Eliciting Activities (MEAs) in a single semester. Students' perceptions of the feedback they received were identified from interviews with 41 students. Students' subsequent course assignments were used to identify how they responded to the feedback they received.

Students stated that GTA feedback was helpful and they preferred clear and specific feedback over vague and generic. Students believed that they made changes based on the feedback they received, but the extent of the actual changes varied. Major themes from the interviews, the impact of the feedback on students' solutions, and recommendations for improving the feedback system will be discussed. (Received September 25, 2012)

1086-N5-2489 **Melissa L Goss*** (melissa.goss@unco.edu), 501 20th St, Campus Box 122, Greeley, CO 80639, and **Rebecca Anne Dibbs** (rebecca.dibbs@unco.edu). *Group Norms Establishment and Enculturation into a Calculus 2 Classroom using the Approximation Framework*. Preliminary report.

The establishment of certain social norms, sociomathematical norms, and classroom practices can foster meaning-making and sophisticated mathematical reasoning. A Calculus 2 course taught from a reform curriculum may include a mix of students who participated in a calculus 1 course taught within the same curriculum and those who did not. The purpose of this educational ethnography is to understand how group norms are established and how students are enculturated into a calculus course taught within the approximation framework. Participants in this study consisted of 24 students enrolled in one section of Calculus 2 at a public university in the Rocky Mountain Region. Classroom practice was observed in whole group lecture and small group work lab days, and 4 students were interviewed to inquire into students' perspectives of the class practices and effects on their learning. Results show strong computational knowledge aids in understanding of approximation framework concepts regardless of Calculus 1 experience. Students who do not complete the pre-lab assignments defer to group peers. Students also defer to a subset of the group to perform computations on a calculator and may or may not evaluate if their group members' computations make sense or are correct. (Received September 25, 2012)

1086-N5-2514 **James S Rolf***, 10 Hillhouse Avenue, Department of Mathematics, Yale University, New Haven, CT 06520, and **Bradley Warner** and **Lauren Scharff**. *Peer Instruction via Learning Catalytics Compared to Active Learning*. Preliminary report.

We report on the impact of peer instruction facilitated by Learning Catalytics software on conceptual understanding as compared to the use of other active learning techniques. Learning Catalytics is a software implementation of clicker technology with many types of questions and a grouping algorithm that can be used to match students for peer discussions. We will report on similarities and differences in performance on conceptual questions, computational questions, and attitudes between treatment and control groups. This study was conducted at the United States Air Force Academy and Yale University in the Fall of 2012. (Received September 25, 2012)

1086-N5-2826 **Warren J Code*** (warcodes@math.ubc.ca), 121 - 1984 Mathematics Road, Vancouver, BC V6T1Z2, Canada, and **Costanza Piccolo**, **David Kohler** and **Mark MacLean**. *Better student learning in a large calculus classroom via higher engagement: a comparison of teaching methods*.

Similar to a widely-reported study in Physics Education Research by Deslauriers, Schelew, and Wieman (Science, 2011), we have implemented a classroom methods comparison in Calculus 1: each of two sections (150-200 students per section) of the same course at a research-focused university were subject to an "intervention"

week where a less-experienced replacement instructor encouraged a much higher level of student engagement by design. Our instructional choices encouraged active learning (answering “clicker” questions, small-group discussions, worksheets) during a significant amount of class time, building on assigned pre-class tasks. The lesson content and analysis of the assessments were informed by existing research on student learning of mathematics, and further steps were taken to enhance the design of our quasi-experiment. We report improved student performance, on conceptual items in particular, in the higher engagement section in both cases. In this talk, we will briefly introduce the overall comparison design which resulted from our setting as well as some of the key assessment items and results. (Received September 25, 2012)

1086-N5-2845 **John C Merkel*** (john.merkel@gmail.com) and **Farouk Brania**. *Peer Led Team Learning in Calculus I: A five year study.*

In Peer Led Team Learning (PLTL) teams of 4-6 students engage in collaborative learning guided by a peer leader. Peer leaders, who attend a training workshop and work closely with the instructors, are students who have successfully completed the course. Since 2006, Morehouse College, an all-male HBCU, has implemented PLTL in calculus I courses. Data was collected over five years from courses, both PLTL and non-PLTL, taught by the presenter. We examine learning gains, retention, and attendance in PLTL sections. (Received September 25, 2012)

1086-N5-2884 **Costanza Piccolo***, costanza@math.ubc.ca, and **Warren Code**. *Insight on students' thinking as they solve related rates problems.* Preliminary report.

This study started with a thorough analysis of student work on problems involving related rates of change in a first-year differential calculus course at a large research university. In two sections of the course, we coded and analyzed students' solutions to geometric related rates problems on various course assessments (quizzes and exams), and tracked students' learning throughout the term. Our findings revealed a widespread, persistent use of algorithmic procedures to generate a solution, observed in both the treatment of the physical and geometric problem, and the approach to the differentiation. To investigate students' understanding of related rates further, we conducted “think-aloud” interviews with some students after they completed the course. In this talk, we will present an analysis of the student thinking observed during the interviews, and what insight we gained about typical student misconceptions involving related rates. We will discuss how our results compared with, and possibly enhance, existing work on student difficulties with related rates problems. (Received September 25, 2012)

1086-N5-2890 **Kristen Joy Schemmerhorn*** (kschemmerhorn@dom.edu), Dominican University, 7900 W Division St, River Forest, IL 60305. *Excursions on the Sphere: Investigation of the Effectiveness of Spherical Geometry to Deepen Understanding of Euclidean Geometry.* Preliminary report.

Spherical geometry is one of many non-Euclidean geometries one can study in a Modern Geometry course. In this project, I examine whether, and the extent to which, discovery-based inquiry activities in spherical geometry will deepen student understanding of Euclidean geometry. This will be accomplished through the use of pretest/post-test data along with qualitative self-reflection from the students. (Received September 26, 2012)

Student Success in Quantitative Reasoning

1086-P1-2061 **A Al-Hasan*** (naser.alhasan@newberry.edu), 2100 College Street, Newberry, SC 29108. *Mathematics for the Liberal Arts, an Interdisciplinary Approach.*

This talk will describe an introductory undergraduate interdisciplinary course which involves a significant mathematics component. Professors from other departments will be guest speakers to relate the mathematics learned to their perspective disciplines. (Received September 24, 2012)

1086-P1-2088 **Cinnamon Hillyard*** (hillyard@carnegiefoundation.org) and **Karon Klipple** (klipple@carnegiefoundation.org). *Quantway and Statway: Successful Models for Teaching Quantitative Reasoning.*

The Carnegie Foundation for the Advancement of Teaching has developed two new pathways, Quantway and Statway, that replace a sequence of mathematics courses that can take as long as two years to complete once students are placed into developmental math. Carnegie's pathways are designed to accelerate this process, by integrating developmental and college-level content into a single year-long statistics or quantitative reasoning course. We will describe how using context-driven problems rich in quantitative and statistical reasoning have helped us achieve high success rates. We will outline the learning objectives for our pathways, which include

attention to quantitative and statistical literacy as well as communication, information, and visual/spatial literacies. We will provide examples of the curriculum that meet these objectives. We will describe the support systems needed to assist diverse faculty and students in transitioning to these new teaching and learning modes. (Received September 24, 2012)

1086-P1-2157 **Aldo R. Maldonado*** (aldo.maldonado@gmail.com), 15300 Cadoz Dr., Austin, TX 78728. *Teaching Multiple linear regression to business students.*

Presenter will describe the difficulties of teaching/learning Multiple linear regression concepts to undergraduates students majoring in business administration. Lessons learned and challenges to overcome will be emphasized. The school in question is a private not for profit national university with satellite campuses all over the US. (Received September 24, 2012)

1086-P1-2277 **Dominic Klyve*** (klyved@cwu.edu), 400 E University Way, Ellensburg, WA 98926, and **Stuart Boersma**, 400 E University Way, Ellensburg, WA 98926. *Promptless instruments and Habits of Mind: Quantitative Literacy as an honors course.*

At many schools, quantitative literacy is offered as a remedial course – sometimes it is even an alternative to pre-calculus. In this talk, we discuss two aspects of a recent attempt to teach quantitative literacy as an honors course. We taught the class using the approach of Madison, et al., in which the students read newspaper articles and learn to reason about them quantitatively. We taught the course both to students in the general population and to groups of honors students. We compare the extent of their learning on problems involving percents. We also compare their performance on a new promptless instrument which we developed. We will discuss this instrument and its efficacy in measuring habits of mind. (Received September 25, 2012)

1086-P1-2314 **Bernard L. Madison*** (bmadison@uark.edu), SCEN 301, Mathematical Sciences, University of Arkansas, Fayetteville, AR 72701. *Reverse Engineering a Quantitative Reasoning Course.*

In the absence of generally accepted content standards and with little evidence on the learning for long-term retrieval and transfer, this is a report on one way to design or evaluate the design of a QR course. A QR course with college algebra as a prerequisite has been taught for 8 years and is being modified slightly to be offered as an alternative to college algebra. One modification is adding a significant formal writing component. As the modification occurs, the current course and the modified one is judged according to six sets of criteria: the six core competencies of the AAC&U QL rubric, the five mathematical competencies from Adding It Up, the eight CCSSM practice standards, the five elements of effective thinking of Burger and Starbird, the summary research findings on human cognition from How People Learn, and the ten principles gleaned from applying the science of learning to university teaching. (Received September 25, 2012)

1086-P1-2346 **Jennifer A. Bruce*** (jennifer.bruce@maryvillecollege.edu). *A Liberal Arts Quantitative Literacy Seminar Becomes an Institutional Research Team.* Preliminary report.

In an increasingly assessment-driven climate, a small liberal arts college was struggling with the question of quantitative literacy of its students. How quantitatively literate are our students? (Not very, we think, but we don't know for sure.) Which subgroups have weaker quantitative literacy skills? (We have no idea.) How do we increase our students' literacy levels? (Hopefully with our general education statistics course, but we don't know if that's helping.) This presentation will describe an experimental first year liberal arts seminar course that transformed a group of freshmen into a team of institutional researchers trying to answer these questions with real data. We will describe the course design, the assessment instrument, the data collection and analysis, and how the results of this course are impacting this class of students, our entire student body, and the way we think about our curriculum. (Received September 25, 2012)

1086-P1-2437 **Caren Diefenderfer*** (cdiefenderfer@hollins.edu). *First and Second Year Quantitative Reasoning Courses according to Members of the National Numeracy Network.* Preliminary report.

The National Numeracy Network (NNN) will hold its annual meeting in mid-October 2012 in New York City. The NNN is an interdisciplinary group of professionals who are interested in quantitative reasoning. A number of NNN talks will focus on courses for first and second year students. I will summarize the talks and give an overview of new developments, with an emphasis on courses taught by faculty members in departments other than mathematics. (Received September 25, 2012)

- 1086-P1-2518 **Andrew J. Miller*** (andrew.miller@belmont.edu). *Quantitative Reasoning through Consumer Finance*. Preliminary report.

Since 2009, I have been teaching an interdisciplinary, problem-based course called “Quantitative Literacy and Consumer Finance.” In this course, students learn quantitative and communication skills through the exploration of real-world scenarios in consumer finance. Students consider the mathematical, financial, political, legal, and social aspects of such issues as credit cards, payday lending, finance regulation, student loans, budgeting, and financial literacy curricula. In this presentation I will focus on a few of the student activities and highlight the quantitative reasoning skills addressed in each task. (Received September 25, 2012)

- 1086-P1-2608 **Theresa Laurent*** (tlaurent@stlccop.edu), 4588 Parkview Place, St. Louis, MO 63110. *Incorporating More Quantitative Reasoning in an Applied Calculus Course*.

Can we assume that Calculus students possess adequate quantitative reasoning skills? We all ask our students to do calculations to determine mathematical competence, but unless we ask students to interpret, represent, apply, analyze, and communicate mathematics, we can’t assess the level of their quantitative reasoning skills. This presentation will discuss how the Association of American Colleges and Universities’ Quantitative Literacy VALUE Rubric was used to enhance quantitative literacy in an Applied Calculus course. In the revised course, students spend more time on communicating the contextual meaning their results, creating multiple representations of given information, and applying their calculus skills to mathematical models. In this talk, many examples of these problems and assessments will be shared. (Received September 25, 2012)

- 1086-P1-2680 **Chris Oehrlein*** (cdoehrlein@gmail.com), 1320 SW 122nd St, Oklahoma City, OK 73170. *Guided Discovery and Concept Development in Applied Calculus*.

Business or Applied Calculus courses sometimes get a reputation for being “Calculus Lite” void of very much rigor. On many campuses they get second-class treatment - larger class sizes, more pure lecture from graduate students or adjunct instructors who may get little in the form of training or creative ideas for reaching students who need to understand the concepts of calculus and how they can be applied in disciplines outside math, physical sciences and engineering. These are students who need instead to be deliberately engaged with the concepts - given a chance to explore geometric, graphical, numerical and symbolic aspects of the subject in the context of biology, psychology, finance and marketing (just to name a few areas). It is very easy to adapt exercises in the textbooks into guided discovery activities that help develop the concepts (and give practice with the computational aspects) and encourage collaboration (which in turn can help build confidence among some of the more math-anxiety ridden members of the class). The presenter will share his approach, rubrics, course grading, and student feedback from his attempts to make the Applied Calculus course more meaningful and useful. (Received September 25, 2012)

- 1086-P1-2688 **Susan L. Ganter*** (ganters@ecu.edu) and **William E. Haver**. *Partner Disciplines and Implications for the Mathematics Curriculum: Moving Forward with the Curriculum Foundations Project*.

The recommendations from MAA’s Curriculum Foundations Project, first focusing on the needs of students majoring in “mathematics intensive” disciplines and subsequently on those from the social sciences and humanities, present an opportunity and a challenge to mathematics departments. Disciplinary representatives were unanimous about the need to develop in students a conceptual understanding of the basic mathematical tools while grounding the discussions in context—in spite of the vast differences between the disciplines represented. Their reports provide guidance on the fundamental skills required for each discipline and emphasize that the abilities most valued are problem solving skills, mathematical modeling, communication skills, and command of appropriate technology. The specific topics are not as important as 1) technical confidence; 2) the application of mathematics to a variety of contexts; and, 3) the ability to choose appropriate technical tools. Given this compelling information, the need to rethink and revise introductory mathematics courses (such as Quantitative Reasoning and College Algebra) is critical. This session will focus on next steps in this process, including current work in College Algebra and possible ideas for continuing projects. (Received September 25, 2012)

- 1086-P1-2951 **Gregory D. Foley*** (foleyg@ohio.edu), Ohio University, 117 McCracken Hall, Athens, OH 45701-2979. *Dual Credit for Quantitative Reasoning Courses: What Are the Challenges?*

In the United States, courses in Quantitative Reasoning have been gaining traction at the postsecondary level over the past two decades. When well conceived and executed, such courses simultaneously can develop mathematical proficiency, statistical reasoning, and quantitative literacy. They can strengthen student understanding of algebra, geometry, functions, and trigonometry while building student understanding of statistics, probability,

and modeling. The broad range of content in Quantitative Reasoning makes more sense for many college and university students than the narrow range provided by College Algebra, which has preparation for calculus as a key goal. Many U.S. colleges now offer college credit to a student who completes a College Algebra course while still enrolled in high school. This is encouraging high schools to offer such courses instead of Quantitative Reasoning courses, which may better serve their students. Should colleges offer college credit to a student who completes Quantitative Reasoning? This talk explores the issue of dual credit, its consequences, and the obstacles it places on innovative courses in Quantitative Reasoning. (Received September 26, 2012)

1086-P1-2960 **Ray E. Collings*** (ray.collings@gpc.edu), Georgia Perimeter College, Department of Math, Comp. Sci, Engineering, 555 North Indian Creek Drive, Clarkston, GA 30021.
Project Infinity, A Preliminary Report.

Our use of infinity in the mathematics classrooms of freshman and sophomore is confusing and frustrating to many of our college students at Georgia Perimeter College. A 1-year STEM mini-grant project is underway to improve instruction involving infinity in such applications as asymptotes, limits, Riemann sums, and series representations of functions. Preliminary results from the Fall Semester 2012 will be presented, including work gathered with students using i-Pads and the Note Taker HD. (Received September 26, 2012)

Touch It, Feel It, Learn It: Tactile Learning Activities in the Undergraduate Mathematics Classroom

1086-P5-149 **Jenna Price Carpenter*** (jenna@latech.edu). *Enticing Your Students to be Sweet on Equivalence Relations: A Tactile Approach to De-Mystifying an "Abstract" Concept.*

The first time that students encounter the concept of an equivalence relation is often in a first proofs course. For many of these students, such a course is their first glimpse into the abstract underpinnings of mathematics. Many textbooks present equivalence relations, which we actually use in our everyday reasoning, from an abstract viewpoint. Providing students, or teams of students, with bags of assorted pieces of individually-wrapped candy at the outset of the discussion on equivalence relations can give them a tactile and visual way to test, verify and even discover concepts and theorems about equivalence relations on their own as you move through the material. This talk will take you through this approach to teaching equivalence relations and let you play along, as well. (Received July 29, 2012)

1086-P5-261 **Justin A. Brown*** (jbrown7@olivet.edu), One University Ave, Bourbonnais, IL 60914, and **Dale K. Hathaway.** *Finding Groups in a (New) Color Cube Puzzle.* Preliminary report.

Abstract Algebra students are given 27 small cubes, three each of nine different colors, and asked to construct a $3 \times 3 \times 3$ cube in such a way that each color is represented exactly once on each of the 6 faces. They are then given particular operations on the blocks that result in different color arrangements while still preserving the property that each color is represented exactly once on each face. Students are asked to identify the group formed by the operations and their compositions. Since some operations lead to an identical arrangement of colors, this group has relations among the compositions of operations, which students are also asked to identify. Surprisingly, students' answers will vary depending on their initial solutions of the puzzle!

We will discuss different options for the choice of operations on the blocks, which allow this activity or project to take on varying levels of difficulty. (Received August 14, 2012)

1086-P5-571 **Carolyn Yackel*** (yackel_ca@mercerc.edu), 1400 Coleman Ave., Dept. of Mathematics, Macon, GA 31207. *Developing Riemann Sums via a Paper Shredder.* Preliminary report.

We discuss an activity in which students cut interesting shapes out of colored paper, try to naively estimate their areas, and then approximate the areas after running the shapes through a paper shredder. This activity gives a natural entry point for discussion of many issues surrounding Riemann sums for from the most obvious (e.g., the formula and the limit) to the quite subtle (e.g., differing partition sizes). Details and variants of the activity will be included. (Received September 07, 2012)

1086-P5-782 **Hannah R Robbins*** (robbins@roanoke.edu). *A Hands-On Introduction to Knot Theory.* I have taught basic knot theory a number of times, and each time I have started with the same activity. Small groups of students are given a bag of knots and asked to work together to answer the most basic question of knot theory: Which of their knots are the same?

This activity has been a great success every time! It works on a number of levels: motivating students to care about knot theory, getting them thinking about how to create a good (mathematical) definition of “the same”, and getting them talking to each other to support their ideas.

In this talk we will discuss how to facilitate the students investigation and discussion, as well as how to modify the activity for students with differing levels of mathematical sophistication. (Received September 12, 2012)

1086-P5-795 **Angela Hare*** (ahare@messiah.edu). *Tactile Activities to Enhance Learning in Algebra and Trigonometry.*

The author describes tactile and physical teaching activities used in a summer program for blind students learning algebra. Examples include tactile graphs and charts, physical demonstrations to illustrate abstract concepts such as the distributive property, and other kinesthetic activities suitable for teaching algebra and trigonometry. The author will also discuss student reactions, educational benefits of tactile activities and universal design, and tips for carefully designing math activities that maximize learning and minimize preparation time and cost. (Received September 12, 2012)

1086-P5-880 **Cayla D McBee*** (cmcbee@providence.edu). *Engaging Calculus Students with Tactile Learning Activities.*

Many topics in calculus lend themselves well to tactile learning activities. These activities help keep students engaged while building understanding and mathematical intuition. I will discuss specific activities I have used in my calculus classes. Examples include using Play-Doh and floss to study volumes by slicing and using yarn and masking tape to create giant graphs of functions. I will discuss how I incorporated each activity into the class and I will present the written materials that accompanied each lesson. I will also review how the lessons went and provide student feedback on each activity. (Received September 14, 2012)

1086-P5-902 **John C Mayer*** (jcmayer@uab.edu), Department of Mathematics - UAB, Birmingham, AL 35294-1170. *An Open-Ended Problem: Hexagon Numbers.*

An *equiangular hexagon* is a six-sided convex polygon all of whose internal angles are equal. Imagine that you have an unlimited supply of congruent equilateral triangles. A number of these triangles can be placed with edges adjoining (fully, not overlapping) so as to form an equiangular hexagon. The first two hexagon numbers are six and ten. Call a positive integer n a *hexagon number* provided that with n of your congruent equilateral triangles, you can build an equiangular hexagon. *What are the hexagon numbers?* We will show how, using manipulatives, this problem, and others that flow from it, can be introduced to students, working individually or in collaborative groups, in grades 5-16. There are multiple entry- and exit-levels for this problem. Such problems help students understand what mathematics actually is, as a study in its own right as opposed to (merely) a tool. (Hexagon numbers are not to be confused with *hexagonal numbers*: The n^{th} hexagonal number is the number of points on a regular hexagon with n regularly spaced points on a side, including the vertices.) (Received September 15, 2012)

1086-P5-978 **Zachary A. Kudlak***, 330 Powell Avenue, Division of Mathematics & IT, Newburgh, NY 12550. *Modeling Bodies of Revolution in Calculus.* Preliminary report.

A common exercise in many second semester calculus courses is to calculate the volume of bodies of revolution, for example see Stewart, *Calculus – Concepts and Contexts*, Chapter 6. We propose an exercise to model a rotationally symmetric object that students have brought to class, such as a vase, bottle, or glass. Through the use of open source software and a computer algebra system, we give a method of taking a digital image of a real life object with rotational symmetry, and creating a mathematical model from the image. We can use either *Mathematica* or *Maple*, depending on institutional licensing, or an open source alternative, such as *Sage*, to display a 3D rendering of the mathematical model and to calculate the volume. The resulting volume can be compared to the volume of the actual object; depending on available class time, students can measure the volume by submersion in water or other approach. (Received September 17, 2012)

1086-P5-1227 **Sandra Richardson** (srichardson@vsu.edu), Department of Mathematics & Computer Science, Virginia State University, PO Box 9068, Petersburg, VA 23806, and **Debbie Gochenauro*** (dlgochenauro@ship.edu), Department of Mathematics, MCT 250, Shippensburg, PA 17257. *Tactile Learning Tasks to Enhance the Content Knowledge of Mathematics Pre-service Teachers.*

In order to accommodate variation in students' learning styles and how one perceives and processes information, special focus must be placed on enhancing the content and pedagogical knowledge of elementary and middle school pre-service teachers. A prominent way of accomplishing such enhancement is through the use of tactile

teaching methods and activities in undergraduate mathematics courses for pre-service mathematics teachers. We will present mathematics tasks and activities used with pre-service mathematics teachers in undergraduate mathematics courses to engage them in the development of transformative pedagogical and content knowledge, allowing students to experience concepts in new and exciting ways. (Received September 20, 2012)

1086-P5-1500 **Mary K. Flagg*** (mflagg@math.uh.edu), Department of Mathematics, University of Houston, 641 Philip Guthrie Hoffman Hall, Houston, TX 77204-3008. *Juggling Finite Mathematics*.

No, I don't juggle, but I use a bag of juggling balls to illustrate the concepts of combinations and permutations in my Finite Math classroom. I often teach a large section of finite, my fall section has nearly 300 students. Therefore, many of the more interactive activities are not practical. However, my students really need tactile examples of the number of ways to choose a certain number of objects drawn at random from a container of some sort. I use a clear plastic box with a collection of six to eight inch diameter balls. They are large enough for most students to see, yet small enough to carry. I often take my props with me to the tutoring center, and many of the struggling students find hands on examples very helpful. I am teaching 2 sections of finite math this fall, and plan on using this activity in only one of them. I will demonstrate my activity and present my results on the difference the activity made in student understanding. (Received September 22, 2012)

1086-P5-1580 **Stacy L. Hoehn*** (shoehn@franklincollege.edu), 101 Branigin Blvd, Franklin, IN 46131. *Hands-On Activities in a College Geometry Course*.

When learning concepts in a college geometry course, looking at drawings on a two-dimensional sheet of paper or even manipulating constructions in a computer program is not always enough to help students truly understand what is happening and why. In this talk, I will describe a number of tactile and hands-on activities that can be used to supplement student learning about a wide range of geometric ideas, from triangle congruence and proofs of the Pythagorean Theorem to three-dimensional geometry and spherical geometry. (Received September 23, 2012)

1086-P5-1801 **Thomas C. Hull*** (thull@wne.edu). *Origami, volume, and dissections of the cube*.

Molly's Hexahedron is a very simple origami model that makes a hexahedron where each face is a 45° right triangle. Calculating the volume of this solid is a straight-forward geometry exercise, but the answer seems very counterintuitive. Making sense of the answer leads to a hands-on exploration of the nature of volume measure and to some interesting dissections of the cube. (Received September 24, 2012)

1086-P5-1867 **Monica M VanDieren*** (vandieren@rmu.edu), 6001 University Blvd, Robert Morris University, Moon Township, PA 15108. *Visualizing Multivariable Calculus with paper, Play-Doh[®], blocks and CalcPlot3D-generated models*.

This presentation will describe the use of physical models in a Multivariable Calculus class at Robert Morris University. Interactive classroom activities exploring concepts such as intersecting surfaces, arc length, curvature, tangent lines to parametric curves, contour lines, cylindrical and spherical coordinate systems, tangent planes, gradients, directional derivatives, and double and triple integration will be shared. Each of these classroom activities features a low-cost physical model that the students construct from paper, Play-Doh[®] or blocks. The activities not only introduce students to the graphical concepts but also reinforce student understanding of graphs which they have generated with a freely available Java applet called CalcPlot3D. Additionally, this presentation will illustrate how the CalcPlot3D applet can be used to create physical models using 3D printers. CalcPlot3D is part of an NSF-funded grant project called Dynamic Visualization Tools for Multivariable Calculus (DUE-CCLI #0736968). See <http://web.monroec.edu/calculNSF/> (Received September 24, 2012)

1086-P5-1943 **Julie Barnes*** (jbarnes@email.wcu.edu), Department of Mathematics & Computer Science, Western Carolina University, Cullowhee, NC 28723. *Ball toss, crackers & cheese, and line dancing: Concrete ways to help students understand functions in precalculus*. Preliminary report.

In this talk, we look at a variety of ways to help students understand functions using tactile teaching techniques. In particular we will use a ball toss to explain the definition of a function, an activity with crackers & cheese to demonstrate function composition, and line dancing to practice shifting and stretching functions. (Received September 24, 2012)

- 1086-P5-1994 **Shelly Smith*** (smithshe@gvsu.edu). *Hands-on Calculus Using 3-D Paper Models.* Preliminary report.

Students often find it challenging to visualize 3-D objects when solving optimization applications or calculating volume in Calculus classes. In this talk, we describe an activity where students fold origami boxes of various sizes to gather data about the dimensions of the boxes to predict the height of the box with the maximum volume. The students then use the creases of the unfolded boxes to create a theoretical model for volume, and calculate the maximum of the function. This theoretical model can be extended to boxes folded from a square sheet of paper of any size. We also describe using tissue paper party decorations as models for calculating volume. Students use regression models to create a 2-D region that is rotated around the x-axis to create a solid of revolution. They divide the resulting 3-D object into appropriate sections and calculate the volume of each piece using disks or washers. These activities would also be appropriate for lab projects using a CAS. (Received September 24, 2012)

- 1086-P5-2045 **David Clark*** (dcclark@umn.edu). *Hand-on coding theory: Can you hear me now?*

Error-correcting codes are a highly relevant and engaging topic which can also be used as an introduction to advanced mathematics. But how can students experience this key aspect of modern communications without costly electronics? We will describe an activity which introduces students to the fundamental concepts of error-correcting codes by way of hands-on data transmission. The activity requires only pipe cleaners and plastic trays which are easily obtained from many science labs. (Received September 24, 2012)

- 1086-P5-2125 **Johann A. Thiel*** (johann.thiel@usma.edu). *Painting with light: visualizing mathematical concepts using long-exposure photography.* Preliminary report.

Long-exposure photography is a technique that can be used to capture the movement of light in a single image. In this talk, we look at how to use long-exposure photography to help students understand and visualize various mathematical concepts, including: parametric plots, projectile motion, and dynamical systems. Samples and demonstrations of such activities will be given. (Received September 24, 2012)

- 1086-P5-2233 **Robert D. Franzosa***, robert_franzosa@umit.maine.edu. *True/False Edge-Notched Cards: A Hands-on Deductive Reasoning Calculator.*

In the chapter “The Binary System” in *New Mathematical Diversions* from Scientific American, Martin Gardner presents a deck of edge-notched cards that he uses to demonstrate binary sorting, to demonstrate a number trick, and to solve a logic problem. Building on his approach to the logic problem, we show how to use the deck for a hands-on approach to basic deductive reasoning topics typically seen in an introductory abstract mathematics course. In particular, we show how the deck can be used to compare propositions for equivalence, identify tautologies, identify contradictions, construct truth tables, and construct valid arguments. (Received September 25, 2012)

- 1086-P5-2271 **Audrey Malagon*** (amalagon@vwc.edu) and **Lisa Driskell** (ldriskel@coloradomesa.edu). *Keychain Ziplines: A practical way to study velocity in the calculus classroom.*

This talk will discuss an inquiry-based calculus activity to introduce the concepts of average velocity and instantaneous velocity. Using materials that are easy to find, students create a “zipline” for a weighted keychain and measure distances and times to calculate average velocities. They then explore the idea of instantaneous velocity. This activity has been tested as a first day activity in classrooms at a variety of institutions and we have found it to work well as a team building activity and introduction to the first concepts of calculus. (Received September 25, 2012)

- 1086-P5-2272 **Therese Shelton*** (shelton@southwestern.edu). *Building and Feeling Confidence Intervals.*

Students enjoy an in-class activity for creating physical confidence intervals from pipe cleaners and beads for the mean of dice rolls. We know whether the population mean of this known distribution is contained in each confidence interval. The activity is doubly tactile, both in actively generating sample data and in creating an actual object for a confidence interval. The resulting class collection fosters discussion and solidification of multiple major concepts, including the Central Limit Theorem, variation in samples, effect of sample size, and the meaning of confidence interval and confidence level. (Received September 25, 2012)

- 1086-P5-2380 **Sharon Frechette***, sfrechet@mathcs.holycross.edu. *Activities for Creating and Classifying Tessellations of the Plane*. Preliminary report.

A *tessellation* is a planar pattern that exhibits translation in two independent directions, and possibly some combination of the following symmetries: reflections, rotations, and glide reflections. There are seventeen possible symmetry types, often called the “wallpaper groups.” Several related hands-on activities with tessellations will be discussed. The presenter has used versions of these activities with math majors in a linear algebra class, first-year students in a seminar on the connections between mathematics and art, and high school geometry teachers in a workshop on pedagogy. In one activity, students examine Escher prints to determine their symmetry type, using a transparency placed over a copy of the print. By tracing a generating region on the transparency, and then applying rigid motions by the appropriate movement of the transparency, students can determine which rigid motions are symmetries of the given print. In another activity, students create their own tessellations, first choosing the symmetries they want to include, and learning how to cut a generating tile that will create those symmetries when the appropriate rigid motions are applied. (Received September 25, 2012)

- 1086-P5-2382 **Mike Long*** (malong@ship.edu), Shippensburg University, 1871 Old Main Drive, MCT 273, Shippensburg, PA 17257. *Functions at the Club*.

How often have students missed a simple concept related to functions because they did not know how to complete a graphical representation? Students will never forget how to graph ordered pairs or transform functions from the basic library when the process is set to a driving disco beat in an atmosphere reminiscent of 1970s dance clubs. Wear your platform shoes, come join the party, and see how to help your students dance their way to an understanding of ordered pairs and transformation of functions. (Received September 25, 2012)

- 1086-P5-2425 **Elin R Smith*** (smither@kenyon.edu) and **Marie A Snipes** (snipesm@kenyon.edu). *Using the Pottery Wheel to Explore Topics in Calculus*.

Students sometimes struggle with visualizing the 3-dimensional solids encountered in certain integral problems in a calculus class. We designed a project in which students create solids of revolution with clay on a pottery wheel and estimate the volumes of these objects using Riemann sums. In addition to giving students an opportunity for tactile learning, this project focuses students’ attention on concepts relating to (1) functions that have no algebraic formula, (2) notation and construction of Riemann sums, and (3) error estimation. We will describe our project design, implementation, and student reactions. (Received September 25, 2012)

- 1086-P5-2471 **Ann C Hanson*** (ahanson@colum.edu), Science/Math Dept., Columbia College, 600 S Michigan, Chicago, IL 60605. *Learn by Doing*.

In this session, the presenter will demonstrate a variety of “hands on” activities to teach concepts about triangles. For example, an activity will be demonstrated to show that the sum of two sides of a triangle must be greater than the third side by using Geo Strips. Another activity that actively engages students helps them to understand similar triangles. In this activity, the students use rulers and patty paper (or acetate) to show that the triangles they have constructed are similar. At least one more hands on activity will be demonstrated. All of the activities are currently being used at the college level by the speaker and involve very little special equipment. Student reactions and methods for integrating these activities into the curriculum will be shared (Received September 25, 2012)

- 1086-P5-2740 **Jill Bigley Dunham*** (dunham@hood.edu). *Graph (no longer just) Theory*.

I came to graph theory for the cool pictures and stayed for the beautiful proofs, but not everyone has the same learning style. I will present and demonstrate several types of activities that I have used in courses at a variety of levels: a graph theory course for senior undergraduate math majors and graduate-level mathematics education majors, a sophomore-level discrete mathematics course, and a freshman-level liberal arts math course. The activities involve simple props like colored yarn, masking tape, and balloons to give a tactile understanding of concepts and algorithms in graph theory. (Received September 25, 2012)

- 1086-P5-2778 **Jennifer Wilson***, wilsonj@newschool.edu. *Mathematics of Pop-up Books*.

The construction and analysis of pop-up books presents a wonderful opportunity to apply concepts from geometry and linear algebra to problems that arise naturally as the “pop-ups” are unfolded. Historically, one of the earlier pop-up books was Sir Henry Billingsley’s 1570 English translation of Euclid which included several pages with paper-flaps that could be folded up to create three dimensional figures. With the aid of computational geometry, modern pop-up books have become increasingly intricate. In this talk, we look at a number of simple constructions which lead to questions about area, volume of negative space and angles of orientation and how they change as the pages are unfolded. Students develop their own hypotheses as they experiment with variations

on basic constructions. They are then able to test their spatial and tactile intuition using precise mathematical arguments. (Received September 25, 2012)

Transition from High School to College: Alternative Pathways

1086-Q1-777 **Christian Hirsch*** (christian.hirsch@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008. *Transition to College Mathematics and Statistics for Non-STEM Students.*

Transition to College Mathematics and Statistics (TCMS) is a problem-based, inquiry-oriented fourth-year capstone course intended for the large number of high school students planning to enter college programs that do not require calculus. Funded by the National Science Foundation, this new and innovative course is accompanied by *TCMS-Tools*, a suite of Java-based, open source software tools including a spreadsheet, a CAS, and dynamic geometry, data analysis, and discrete mathematics tools and specialized apps such as two- and three-dimensional geometric linear programming. The primary goal of this course is to ensure college readiness for students not pursuing degrees in STEM disciplines. This session will highlight findings of the CBMS 2010 Survey with respect to enrollments in first-year undergraduate mathematics courses and the implications for the transition from high school to college mathematics. The focus will be on the design and development of TCMS, its content and priorities, affordances of the curriculum-embedded software, and preliminary evaluation results. (Received September 12, 2012)

1086-Q1-962 **David Bressoud*** (bressoud@macalester.edu). *Selected Results from the MAA Calculus Study.* Preliminary report.

The session will describe some of the data collected in the MAA's national study of Calculus I, undertaken in fall 2010 as a background for considering issues and concerns as students move from high school to college mathematics. Several members of the MAA/NCTM Joint Committee on Mutual Concerns will discuss the work of the committee related to these issues and briefly describe some typical options that might help address the challenges. They will also set the stage for the remaining papers in the session with the goal of providing an impetus for others to consider what takes place on their own campuses and whether they are serving all of their students well. (Received September 17, 2012)

1086-Q1-1054 **Al Cuoco*** (acuoco@edc.org), 41 Foundry Ave., Waltham, MA 02453, and **Joseph Rotman** (rotman@math.uiuc.edu), 1409 W. Green Street (MC-382), Urbana, IL 61801-2975. *Abstract Algebra for High School Teachers.*

Abstract algebra is required, rightly so, for college students preparing to teach high school mathematics, but the standard course is notoriously unpopular. We describe the course, offer an analysis of its unpopularity, and describe a way to make it more lovable, more aligned with the recommendations in the recent revision of the CBMS book "The Mathematical Education of Teachers" (MET-II) and, above all, more useful.

We have listened to many high school teachers and college educators, and, as a result, we have redone the standard syllabus, without "dumbing it down," so that it better connects with students' prior experience and makes explicit connections to the profession of teaching high school mathematics. The talk will detail our ideas. (Received September 18, 2012)

1086-Q1-1173 **Gregory D. Foley*** (foleyg@ohio.edu), 117 McCracken Hall, Athens, OH 45701-2979. *Advanced Quantitative Reasoning: Mathematics, Statistics, and Modeling for College Readiness and Informed Citizenship.*

Advanced Quantitative Reasoning is an innovative course in mathematics, statistics, and modeling for high school students who have completed Algebra I, Geometry, and Algebra II or Integrated Mathematics I–III. The AQR course is designed to develop mathematical proficiency, statistical capability, and quantitative literacy—filling a critical gap in the nation's high school mathematics course offerings. The traditional core topics of high school mathematics—algebra, geometry, functions, and trigonometry—are combined with the new college and career readiness topics of quantitative reasoning, statistics, probability, and modeling. Motivating questions and engaging investigations are the heart of the course. The AQR course balances reasoning and sense making with communication and in-context problem solving. This talk presents rich tasks that high school seniors find engaging and that leverage mathematical action technologies and classroom discourse. These tasks have been

classroom tested in technology-intensive learning environments focused on language, thinking, and learning. (Received September 19, 2012)

1086-Q1-2004 **Daniel T Kaplan*** (kaplan@macalester.edu), 1600 Grand Ave., Saint Paul, MN 55116.
Calculus is Hard, Change is Harder.

Over the last decades, there have been many calls for change in the transition to college-level math. Some are based on conclusions reached by experienced educators, some based on abstract pedagogical principles, some based on surveys of “client” or “partner” disciplines, some based on analysis of transcripts and similar data about student success and trajectories. Taken as a body, the quantitative research and the qualitative experience of educators indicates that the path of algebra leading to calculus seems not to be providing the majority of students with a useful mathematical preparation. Substantial ingenuity, creativity, and energy have been put into developing alternative pathways and pedagogies, but there is hardly a collective sense of optimism that things are getting broadly better.

There are several large-scale reasons why improving the situation is hard. I’ll discuss some of these and argue that they point to a need for a discontinuous change in our curriculum. I’ll outline one possible approach involving a simple mathematical repertoire, an emphasis on approximation and modeling, and serious engagement with modern computing and data. (Received September 24, 2012)

1086-Q1-2072 **Uri Treisman*** (uri@math.utexas.edu), Dana Center UT Austin, 1616 Guadalupe Street 3.206, Austin, TX 78701. *The New Mathways Project: A Statewide Initiative to redesign the pathways to and through gateway college mathematics courses in Texas.* Preliminary report.

Remedial course sequences are in the policy spotlight as states seek to increase the proportion of students who complete degrees and certificates with labor market value. At the same time, states are increasing the rigor of their K-12 mathematics programs either by adopting the CCSS(M) or by modifying their existing mathematics frameworks. These new state K-12 mathematics frameworks are designed to produce students who are “college ready.” Researchers estimate that perhaps as few as one-third of high school students will meet their state’s college readiness benchmark. And, the evidence on the low success rate in college-level remedial offerings is new well documented and known by policy leaders. The result is a wave of state and system efforts to reform remedial offerings both in K-12 and higher education although these improvement efforts are typically disconnected from each other. The talk will examine the New Mathways Project – a collaboration of the Texas Association of Community Colleges and the Charles A Dana Center at the University of Texas at Austin. We will consider its organizing principles, approach to working at scale in a decentralized education system, and finally its policy and political implications. Comparisons will be made with efforts in other states. (Received September 24, 2012)

1086-Q1-2084 **Karon Klipple*** (klipple@carnegiefoundation.org) and **Cinnamon Hillyard** (hillyard@carnegiefoundation.org). *Quantway and Statway: Successful Pathways To and Through a College Level Math Course.*

The Carnegie Foundation for the Advancement of Teaching has developed two new math pathways, Quantway and Statway, which have demonstrated promising results in their initial implementation. Compared to previous developmental math students from their institutions, students in these pathways have dramatically increased the success rate of passing a math course. Recent studies report that between 60 and 70 percent of students do not successfully complete the sequence of required math courses. These pathways replace this sequence of courses that can take as long as two years once students are placed into developmental math. Carnegie’s pathways are designed to accelerate this process, by integrating developmental and college-level content into a single year-long statistics or quantitative reasoning course. We will describe the design principles and corresponding curriculum for these pathways and share the results from the first year of implementation in 30 colleges. We will demonstrate the need to approach a mathematics pathway as a system of improvement rather than just a curricular change. We will talk about our multi-faceted efforts to improve this system which includes faculty and administrators, online and in class materials, and student and faculty support structures. (Received September 24, 2012)

1086-Q1-2122 **Noah D Finkelstein*** (noah.finkelstein@colorado.edu), Department of Physics, UCB-390, University of Colorado, Boulder, CO 80309. *Physics Education Research: tools for educational transformation at a critical time.*

Currently, unprecedented national attention is now being paid to the outcomes of and needs for educational research within disciplinary fields. After framing the national scale scene of physics education, and how physics education research (PER) is positioned to contribute to the national dialog, I will review the growth of some key tools that have helped transform physics courses. This work develops a new theoretical line of inquiry in PER

through experimental work on student learning in physics at the individual, the course, and the departmental scales. I will present samples of these scales reviewing: course transformation at the introductory to advanced level in physics, research on how subtle faculty choices that influence the impacts of these course transformations, and the development of a framework for understanding (and effecting?) sustained change in undergraduate science math and engineering education. (Received September 24, 2012)

1086-Q1-2586 **Roxy Peck*** (rpeck@calpoly.edu). *Alternative Pathways—Entry Level Mathematics Options.*

Options for entry level mathematics pathways appropriate to a student's chosen field of study will be described. Lower division transfer requirements in mathematics (honored by all three of California's public higher education systems—California Community College System, California State University System and the University of California system) that recognize multiple pathways will also be discussed. (Received September 25, 2012)

1086-Q1-2898 **Michael Hoffman*** (hoffmanm@smccd.edu), 404 Eastmoor Ave., Daly City, CA 94015, and **Amanda Pitts**. *Math Jam! Building Community and Improving Math Placement at Cañada College.*

While many students from underrepresented groups enter the California Community College system with a high level of interest in STEM fields, the majority of them dropout or change majors even before taking transfer-level courses. To facilitate the transition of these students into transfer-level STEM courses, Cañada College, a federally designated Hispanic-serving institution in the San Francisco Bay Area, developed an intensive math placement test review program called Math Jam. This free program involves students taking the placement test before and after one or two weeks of intense work on core math skills. Implementation of the program over the last four years shows success in improving student performance in the math placement test, and success in creating a sense of community among program participants. An analysis of student academic performance in subsequent semesters show significantly higher success and retention rates among Math Jam participants compared to nonparticipants. Since the implementation of Math Jam, enrollments in STEM courses have increased significantly, with a higher rate of increase among minority students.

Data will be presented along with information related to developing and maintaining a program like this on other campuses. (Received September 26, 2012)

Trends in Undergraduate Mathematical Biology Education

1086-Q5-231 **Faun C. C. Doherty*** (fdoherty@washjeff.edu). *The ups and downs of interdisciplinary collaboration: undergraduate research experiences in math and biology.*

For colleges that are not able to support their own mathematical biology majors, concentrations, or fields of study, there is still the possibility of exposing undergraduates to valuable interdisciplinary research experiences. Motivated by interest and available funding, I ventured into two very different interdisciplinary research projects with undergraduates of Washington and Jefferson College. One (2009) was mathematical modeling using graph theory of a genetic mapping problem in the spirit of the original Human Genome Project. The other (2012) was in collaboration with a fellow faculty member who is a geneticist and her biology team. I will describe these experiences, the student's reactions, the biologist's reactions, and my observations on biology – mathematics interdisciplinary research including the challenges and rewards that are inherent in the work. (Received August 09, 2012)

1086-Q5-526 **David Karl Ruch*** (ruch@msudenver.edu), Department of Mathematical and Computer Scien, Denver, CO 80217, and **Joanne Odden**. *Pairing A First Year Modeling Course with Introductory Biology.*

This talk will report on outcomes from teaching a College Algebra with Modeling course to freshmen, with strong ties to an introductory biology course taken by the same set of 24 students during Fall 2012. Numerous examples and assignments in the math course are specifically tied to topics discussed in the biology course, with the biology motivating the mathematical models and the mathematics providing insight into the biology. In particular, mathematical modeling is linked to several labs, including genetics, photosynthesis, and enzyme kinetics. The 24 students taking this pair of courses form a Learning Community within the MSU Denver First Year Success Program. (Received September 05, 2012)

- 1086-Q5-712 **Timothy D Comar*** (tcomar@ben.edu), Department of Mathematics, Benedictine University, 5700 College RD, Lisle, IL 60532. *More Student Research Projects with Biological Models Using Impulsive Differential Equations.*

This talk focuses on undergraduate research projects using impulsive differential equations to model biological phenomena. The first project is an investigation of a density-dependent one predator, two-prey model for integrated pest management using impulsive differential equations. In this investigation, students explored conditions under which both prey species would be eradicated, only one species would be eradicated, and both species would remain within controlled population levels. In addition to studying the long-term dynamics of the system, bifurcation behavior of the stroboscopic map of the system was also explored to reveal complex and varying dynamical behavior. The second project investigates the dynamics of an SEIRV epidemic model with impulsive vaccination. Conditions are found under which the disease-free periodic solution is stable and under which an endemic solution is stable. We will discuss the project work, which includes analysis of the dynamics of these systems, and the student preparation needed to engage in this work. We will also discuss other variations of the models that we have investigated. (Received September 11, 2012)

- 1086-Q5-1963 **Lisa Rogers*** (lrogers@cims.nyu.edu), 251 Mercer Street, New York, NY 10012. *Developing a Calculus Course for the Natural and Physical Sciences.* Preliminary report.

I would like to propose a two semester Calculus course sequence aimed towards first and second year natural and physical science students, preparing them for careers in medicine, interdisciplinary research and education. This course sequence will satisfy requirements for Calculus 1 and 2 while developing students' mathematical intuition and computational and research abilities. A typical course period will consist of a brief lecture period for theory introduction and examples, followed by a student discussion period and a lab/problem solving period for practicing execution of techniques learned in the day's lesson. Students will have small research projects involving the analysis, presentation and replication of a mathematical model from a published scientific paper. Students should leave this course sequence with a knowledge of physically realistic model building, analytical and computational techniques for model execution and an ability to effectively communicate their mathematical ideas. (Received September 24, 2012)

- 1086-Q5-1986 **Dan Hrozencik*** (dhro@att.net), Chicago State University, HWH 332, 9501 S. King Dr., Chicago, IL 60423. *Undergraduate Research in Gene Regulatory Networks.*

Across several summers, the authors have sustained research projects with multiple students in the area of gene regulation. In particular, the students began working on projects comparing the dynamics of discrete and continuous models of three- and four-gene regulatory networks. The projects branched into the study synchronous and asynchronous dynamics and their relation to the network structure. The authors will present information regarding the content of the projects, the prerequisite knowledge of the students conducting the research, as well as information about the resources needed to maintain such an ongoing research program. (Received September 24, 2012)

- 1086-Q5-2003 **Silvia Heubach*** (sheubac@calstatela.edu), Department of Mathematics, California State University Los Angeles, Los Angeles, CA 90032-8204, and **Elizabeth Torres.** *Improving the quantitative skills of life science majors at California State University Los Angeles.*

In response to the BIO 2010 report on transforming undergraduate biology education, faculty from biology, mathematics, physics, biochemistry and computer science applied for and received an NIH T36 grant to support curricular changes. We used a three-pronged approach: 1) modifications in the introductory biology, physics, and mathematics courses for life science majors; 2) an interdisciplinary research seminar connecting the disciplines; and 3) a new bioinformatics minor.

We report on changes in the mathematics curriculum. Three new courses were created: Math 105, Introduction to Mathematical Models in Biology (replacing trigonometry), and Math 204/205 Applied Calculus I/II. In all new courses, the mathematical concepts are introduced and explained in the context of biological applications and terminology. The new sequence started in Fall 2011, and all three courses were taught at least twice. Assessments of student attitudes towards mathematics and its importance show positive change, and pass rates for the course sequence have improved. Workshops for life science faculty to learn or review concepts from the new math courses facilitate incorporation of these concepts into biology courses. Challenges of making and institutionalizing the curricular changes are discussed. (Received September 24, 2012)

- 1086-Q5-2191 **Kevin R. Sanft*** (kevin@kevinsanft.com), St. Olaf College, 1520 St. Olaf Ave., Northfield, MN 55057. *Turn down the volume, turn up the noise: a course module in discrete stochastic modeling and simulation.*

Many biological processes are driven by random interactions between molecules present in small populations. These processes are discrete and stochastic, and display behavior that cannot be captured with traditional ordinary differential equation (ODE) approaches. Gillespie's Stochastic Simulation Algorithm (SSA) provides a method for modeling and simulating biological systems in a way that captures this inherent randomness. The SSA is derived as a Monte Carlo method for approximating the solution to the Chemical Master Equation (a high-dimensional ODE). The SSA is simple enough to be implemented in an introductory course. However, advanced algorithms, numerical considerations, and the StochKit software package are also explored. The ODE model is shown to arise in the large population limit through intuitive transitions, first to a Poisson approximation, then to a Gaussian approximation, that arise as the system volume is increased to the thermodynamic limit. Models from the biology literature, including genetic toggle switches and stochastic oscillators, are used to demonstrate the concepts and highlight the impact of discrete stochastic modeling and simulation in biology. (Received September 25, 2012)

- 1086-Q5-2192 **Robert J Rovetti*** (rrovetti@lmu.edu), One LMU Drive, Los Angeles, CA 90045. *Help, my student doesn't want to code! Two biomath research projects that gently introduce programming concepts in a GUI-based modeling environment.*

Even as scientific computing assumes an ever larger role in modern research and applications in medicine and biology, today's college students are brought up in a world of point-and-click graphical user interfaces (GUIs) and multimedia experiences that bypass the need to understand the underlying software or hardware. Many biology majors, and even a sizeable number of math majors, seem either uninterested in, or afraid of, coding. Here I describe two undergraduate research projects based on GUI-oriented software that employs light to moderate amounts of very-high-level coding. The first is a model of pancreatic beta cells using a system of nonlinear ODEs implemented in Berkeley Madonna, which provides a variety of easy-to-use plotting modules while requiring the underlying equations and numerical integration conditions to be input in a code environment. The second is a cellular automata model of cardiac cells using NetLogo, an agent-based intuitive programming language that includes loops, conditional expressions, and subroutines, while still automating all graphical output. Both projects increased the students' interest and self-confidence in programming while providing a relevant biomathematics-based research experience. (Received September 25, 2012)

- 1086-Q5-2276 **Glenn Ledder*** (gledder@math.unl.edu). *Mathematical Modeling for Biology.* Mathematical modeling is the tendon that connects the muscle of mathematics to the bones of science. It is almost universally neglected in mathematics curricula in the United States, a circumstance that is largely responsible for the well-documented inability of most students to use their mathematical knowledge in science courses. In this talk, I will outline some of the basic principles of mathematical modeling and give examples of how to teach them in the context of a mathematics course for biology students. (Received September 25, 2012)

- 1086-Q5-2512 **D. Brian Walton*** (waltondb@jmu.edu), MSC 1911, Roop 110, James Madison University, Harrisonburg, VA 22807. *UBM Group Seminar Discussions: Grappling with Issues beyond the Curriculum.*

The NSF-funded UBM program at James Madison University required participating students enroll in interdisciplinary, quantitative biology courses (modeling and biometry) as well as participate in a bi-weekly seminar. In addition to basic presentations by participating faculty and students on the individual research projects, this seminar provides an opportunity to discuss issues relevant to the intersection of mathematics and biology that are not typically addressed in the curriculum of courses. This talk will discuss how we used this seminar setting to address issues such as career opportunities in math-biology, quantitative approaches in current literature, and ethical issues particularly relevant to interdisciplinary research. (Received September 25, 2012)

- 1086-Q5-2523 **Lester Caudill*** (lcaudill@richmond.edu), Department of Mathematics and Computer Scienc, Univ. of Richmond, VA 23173. *Integrated Quantitative Science at the University of Richmond.*

Beginning in 2009, the University of Richmond has offered an Integrated Quantitative Science course to first-year students who are interested in math and the sciences. The course involves five instructors per semester, one each from Biology, Chemistry, Physics, Mathematics, and Computer Science. Each semester is organized around a theme of current interest (antibiotic resistance in the Fall and cell signaling in the Spring). We will describe the

genesis, logistics, student profiles and themes of the course, and share lessons learned. (Received September 25, 2012)

- 1086-Q5-2793 **Raina Robeva*** (robeva@sbcc.edu), Sweet Briar College. *“Mathematical Concepts and Methods in Modern Biology: Using Modern Discrete Models” - A Collection of Undergraduate Mathematical Biology Modules.*

A growing number of pre-calculus and introductory calculus courses now utilize difference and differential equations models to address questions arising from biology. At the same time, important alternatives such as algebraic and discrete models are notably absent from the undergraduate landscape - a phenomenon largely due to the lack of appropriate curricular materials. The talk outlines a multi-author collection of modules developed in response to this need titled “Mathematical Concepts and Methods in Modern Biology: Using Modern Discrete Models” and edited by Raina Robeva from Sweet Briar College and Terrell Hodge from Western Michigan University. The modules span a wide range of biological topics including gene regulation, neuronal, metabolic, and epidemiological networks, DNA content, population dynamics, and phylogenetics. The featured mathematics includes graph theory, Boolean networks and finite dynamical systems, probability, linear, polynomial, and abstract algebra, and a number of computational algorithms. Multiple exercises are embedded within each chapter and supplemental materials, including online projects, software, data files, and solution manuals are made available from the volume’s site. The collection will be published by Academic Press in January 2013. (Received September 25, 2012)

- 1086-Q5-2842 **Phillip E. C. Compeau*** (pcompeau@math.ucsd.edu), UCSD Dept. of Mathematics, 9500 Gilman Drive #0112, La Jolla, CA 92093, and **Nikolay Vyahhi**. *Rosalind: Free Bioinformatics Education via Online Introductory Programming.*

Rosalind (rosalind.info) is a new online resource for learning bioinformatics through problem solving and programming. It consists of a self-contained tree of programming exercises of increasing sophistication, which are motivated and woven together by an ongoing biological narrative. Accordingly, we hope to incite a revolution in learning programming via practical scientific problems.

Rosalind is not geared toward students of a specific field. Furthermore, the site is valuable to novices wanting to learn bioinformatics independently (accounting for over 500 beta testers, many of whom live in areas with no bioinformatics education) and can also be used by university professors for automated homework checking.

Few institutions can afford the huge number of TAs required to scale individualized bioinformatics instruction to hundreds of students. Following the lead of massive open online courses such as those offered by Coursera, we intend to build a huge user community that will facilitate collaboration on exercises, thus aiding the scaling of bioinformatics education. For example, Rosalind will serve as the central educational tool used in a spring 2013 course at UC-San Diego for 100 biology undergraduates. (Received September 25, 2012)

- 1086-Q5-2843 **Sophia Jang** (sophia.jang@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, **Nancy McIntyre** (nancy.mcintyre@ttu.edu), Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409, and **G. Brock Williams*** (brock.williams@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *Capturing the Imagination of Freshmen and Sophomore Math and Biology Majors Through Research Experiences.*

We will describe our NSF-sponsored PRISM program which seeks to improve retention of math and biology majors by “getting them hooked” on research from the very beginning of their college experience. Freshmen take a special section of Biological Calculus followed by a semester of Computational Biology. Students in their sophomore year spend 10-15 each week conducting biomath research with TTU faculty.

All of our PRISM scholars participate in an intensive summer research camp. We also invite 6-8 promising high school seniors to the camp. This has served to strengthen our connection to area high schools and broaden the pipeline for future math and biology majors.

We will also discuss the students’ research projects, and our mentoring practices as informed by previous programs. (Received September 25, 2012)

Using Inquiry-Based Learning in Mathematics for Liberal Arts Courses

1086-R1-107 **Ryan P Dunning*** (rdunning1@stmarytx.edu), One Camino Santa Maria, San Antonio, TX 78228. *Introduction to proof in an IBL setting for the liberal arts*. Preliminary report.

While other liberal arts math courses focus on application-oriented topics, I chose to focus on the subject of proof in an IBL setting. Topics covered included logic and set theory. I will discuss course structure and sample problems (both successful and unsuccessful). I will share results of entrance and exit surveys (modified from a survey by A. Schoenfeld), aimed mainly at tracking changes in students' expectations and beliefs about mathematics. (Received July 19, 2012)

1086-R1-372 **James C. Price*** (j.c.price@uafs.edu), University of Arkansas at Fort Smith, Department of Mathematics, 5210 Grand Avenue, P.O. Box 3649, Fort Smith, AR 72913-3649. *Using Dialogue Based Activities and Manipulatives in Inquiry Based Learning*.

Recently, I took over teaching college mathematics at my institution. While talking to my colleagues and consulting various reports on best practices in teaching such a course, I repeatedly came across the word activity. To be honest, I was somewhat perplexed at the time by what an activity in mathematics should be, but I was determined to try to incorporate it into my class. The result of these efforts was a series of dialogue based activities that use manipulatives and inquiry based learning to engage liberal arts students in mathematics. In this talk, I will present one of these activities, which is a dialogue between Pythagoras, an Egyptian Rope-Stretcher, and Hippasus entitled, The Pythagorean Theorem. In it, a student discovers the origins of the Pythagorean Theorem, how it was used to prove the existence of irrational numbers, and how a simple manipulative can be used to prove why it is true. It is designed to help liberal arts students understand how mathematics is discovered and proved. (Received August 26, 2012)

1086-R1-375 **Sloan E Despeaux*** (despeaux@wcu.edu), Department of Mathematics and CS, 424 Stillwell Building, Western Carolina University, Cullowhee, NC 28723. *Oulipo: Applying Mathematical Constraints to Poetry, Prose, Art, Dance, and More in a Mathematics for Liberal Arts classroom*.

Oulipo (Ouvroir de littérature potentielle, or Workshop on potential literature), an over fifty-year old movement that began in France, seeks to apply mathematical constraints to literature and the arts. In this talk, I will give a brief survey of this movement and how I have built a learning module based on it for my MLA course. I will provide examples of student-created, mathematically-constrained poetry, comic strips, dance routines, music studies, and videos. These projects allow my students to apply mathematics to their interests in literature and the arts. (Received August 27, 2012)

1086-R1-445 **Wayne Tarrant*** (w.tarrant@wingate.edu), Department of Mathematics, Wingate University, Wingate, NC 28174. *Using Game Theory in a Math for Liberal Arts course*.

Colleagues in other departments have actually told me that they want the Math Department to teach high school consumer math for our Math for Liberal Arts (MLA) course. It is my preference to teach students to reason for themselves. At the same time I want the students to have practical skills they can use in their other courses and in life. Thus, it is my proposal that we teach rudimentary game theory to our students in MLA courses. In this talk I will discuss how IBL approaches to solving the ultimatum game have worked for me. I will also relate experiences of guiding students to the optimum position for a candidate when the populace holds three different opinions on a continuum of opinions that can be represented by a line segment. I will mention further areas that might be included in such a class and welcome suggestions from the audience. (Received September 10, 2012)

1086-R1-677 **G. Edgar Parker*** (parkerge@guilford.edu), Department of Mathematics, Guilford College, Greensboro, NC 27410. *Moore Method in a Mathematics for Liberal Arts Course*.

Over a period of 30-plus years at Pan American University and James Madison University, the author developed several problem sets that allowed students, for a semester, to model the work of mathematicians within the context of math for liberal arts courses. In this talk, he will trace the development of these courses and discuss how the students have dealt with the problem sets. The course notes include investigations on applied mathematics, groups, geometries, and the complex numbers, each forming the heart of a semester's work. (Received September 11, 2012)

- 1086-R1-983 **Volker Ecke*** (vecke@westfield.ma.edu) and **Christine von Renesse** (cvonrenesse@westfield.ma.edu), Westfield State University, 577 Western Ave, Westfield, MA 01085. *Dance and ribbon patterns in maypole dancing*. Preliminary report.

In medieval village life, maypole dancing was a ritual to celebrate May Day. This pagan tradition was meant to increase vitality and fertility. May Day is still celebrated in this way in many places in Europe and also in the hills of Western Massachusetts. As the dancers circle the maypole holding colored ribbons, intricate and beautiful patterns are created on the pole. The connections between individual dance moves, the dance pattern for the whole group, and the resulting ribbon patterns are the focus of an Inquiry-Based Learning unit we have designed for students in the Liberal Arts. Working in small groups, students inquire into questions such as these: *Imagine watching a maypole dance with 8 dancers and alternating red and white ribbons. Can you tell what pattern will emerge before the dance even starts? What if both partners in a dance couple have the same color ribbon? Or conversely: somebody shows you a particular maypole pattern found on a maypole. Could you invent a maypole dance that would create that particular pattern? How many dancers would you need? What dance moves would you ask the dancers to perform?*

Come and explore what this might look like in your mathematics for liberal arts classroom. (Received September 17, 2012)

- 1086-R1-1457 **Gregory Moore*** (mooregm@gmail.com), Macmillan 104, 170 Main St, Aurora, NY 13026. *Engaging Operations Research Students with a Local Reservoir Management Problem*.

Liberal arts students engaged in a semester-long challenge designing an operating diagram for a local reservoir suffering from a grossly outdated model and disagreement among stakeholders. Unlike working with contrived projects, students spent the semester exploring stakeholders, determining model relationships, gathering data, creating and solving models, evaluating potential solutions and repeating. In addition to mathematical skills, students learned skills relevant to the liberal arts such as communication of ideas (written and oral), social responsibility, and arbitrating benefits between more than five stakeholders relying on the water.

This talk will discuss why this inquiry-based problem was selected as part of operations research course, followed by advantages and pitfalls of integrating such an approach into courses. Tips on initiating conversion with project related industry professionals will also be presented. (Received September 22, 2012)

- 1086-R1-1492 **Ali S. Shaqlaih*** (ali.shaqlaih@unt.edu), Dept. of Mathematics and Information Sciences, University of North Texas at Dallas, 7400 University Hills Blvd, Dallas, TX 75241. *Hybrid Inquiry Based Learning in Math for Elementary Teachers Courses*.

Hybrid Inquiry Based Learning (HIBL) is a modified version of the Inquiry Based Learning model (IBL). It integrates the traditional teaching approach with the Inquiry Based Learning approach. In this talk, I will present how I used HIBL to teach a Math for Liberal Arts course to elementary teachers. A practical realistic implementation of the HIBL in classroom settings will be presented. A description of the HIBL approach, how students were engaged and how they responded, the challenges, the assessment methods, and students' achievement will be discussed. (Received September 22, 2012)

- 1086-R1-1495 **Susan K Staats*** (staats@umn.edu), 206 Burton Hall, 178 Pillsbury Dr SE, University of Minnesota, Minneapolis, MN 55418. *Interdisciplinary Math for Non-STEM Students: Curriculum Design to Facilitate Faculty Teaching Across Disciplines*. Preliminary report.

Interdisciplinary math curriculum can offer non-STEM, liberal education students a challenging and relevant alternative to traditional offerings, particularly when it explores connections between math and the social sciences and humanities. Moreover, interdisciplinary learning is inherently inquiry-based. However, faculty members may feel uncomfortable teaching outside of their discipline. This paper describes an approach to designing authentically interdisciplinary math curriculum that a single mathematics instructor can deliver. A sample module, co-written by a math teacher, a disciplinary specialist, and a creative writer, is discussed. The module has been used for three years in an algebra class for non-STEM majors that functions for many students as a liberal education class. Students practice the mathematics of finance through the context of a classic theory in psychology, Erik Erikson's model of life stage development. Erikson's theory suggests that people pass through a series of identity crises throughout their lifespan. Students write short stories that pose identity crises for their characters and that model their characters' resulting financial behaviors using the mathematics of annuities and amortizations. Samples of student work will be provided. (Received September 22, 2012)

- 1086-R1-1615 **T J Hitchman*** (theron.hitchman@uni.edu) and **Doug Shaw** (shaw@math.uni.edu). *Tailoring IBL techniques to liberal arts mathematics classes without losing integrity or quality.* Preliminary report.

At the University of Northern Iowa we have found our MLA students have been receptive to IBL techniques which has taken them farther than the traditional course. We have discovered that small but significant modifications in common IBL techniques can be effective for reaching the liberal arts audience. In this talk we share specific techniques, challenges, and resolutions, and share problem sequences for various topics. Emphasis will be on “nuts and bolts” ideas that you can take back to your classroom. (Received September 23, 2012)

- 1086-R1-1881 **Russell D. Blyth*** (blythrd@slu.edu). *Improved appreciation of mathematics through an IBL liberal arts mathematics course.* Preliminary report.

The author has taught an inquiry-based liberal arts mathematics class using the text “The Heart of Mathematics” by Burger and Starbird sixteen times since spring 2001, during which time he has gathered responses from students that illustrate significant changes in their attitudes towards mathematics during the course. In particular, the responses gathered at the end of the semester are often eloquent about understanding the great ideas of mathematics that are made accessible to students in this course and about seeing connections between mathematics and the “real world.” (Received September 24, 2012)

- 1086-R1-2038 **John Paul Cook***, jpcook@usao.edu. *Making the Abstract Concrete: Teaching Rings and Fields in a Liberal Arts Mathematics Course.*

While the theory of rings, integral domains, and fields is often out of reach of the typical undergraduate student, the ideas that characterize and differentiate between these structures are quite concrete and accessible. This talk will report on an effort to give students in a freshman liberal arts mathematics course (at a public liberal arts university) a discovery- and inquiry-based glimpse into the core ideas of abstract algebra. In particular, the results will include how these liberal arts students with no prior exposure to advanced mathematics built upon their intuitive notions of solving equations to reinvent and come to terms with the basic structures of ring theory. (Received September 24, 2012)

- 1086-R1-2328 **Teresa E. Moore*** (moore@ithaca.edu), Ithaca College, Mathematics, 953 Danby Rd., Ithaca, NY 14850, and **L. Christine Kinsey**. *Exploring the Math of Celtic Knots.*

Inquiry based learning is the foundation from which we teach liberal arts math at our institutions. Students work in groups from materials we provide which guide them to explore, discover, conjecture, test and verify mathematical results. We will present our unit on Celtic Knots. It is one of the first topics students see in our classes so the mathematics is not complicated. However, the students are adjusting to the process of inquiry and learning how to attack problems. We act only as guides when the students are stuck and frustrated. The materials we will present take two or three class periods and allow students to work on paper to draw knots and with manipulatives to fully understand the construction process. Students discover rules for when knots will have loose ends, for where those ends will fall, and for how many strands a particular knot will have. Realizing that simple mathematical concepts can predict complicated structures prepares the students to approach more complicated problems with an open mind and the feeling that they can succeed at finding the pattern and resolving the conflict. (Received September 25, 2012)

- 1086-R1-2473 **Michael Starbird***, starbird@mail.utexas.edu. *Teaching Effective Thinking.*

Students in a liberal arts mathematics course will think every day of their future lives. If their mathematics course can help them to think more effectively in every part of their lives, then that experience will have made an important contribution to their lives. We can describe some thinking skills that can be taught and learned. When independent thinking and creativity are clearly selected as goals for the class, then it becomes clear that active, inquiry-based learning methods of instruction will promote those goals. (Received September 25, 2012)

- 1086-R1-2766 **Yousuf George*** (cgeorge0@naz.edu), 4245 East Ave., Rochester, NY 14618. *A Math Circle as an MLA Course.*

Math Circles have been a fixture in the mathematical culture of eastern Europe for decades, but have only appeared in the United States in the past eighteen years. Math Circles are a form of outreach that bring pre-college students in direct contact with mathematicians with the primary goal of fostering a passion for mathematics through Inquiry-Based Learning.

Inquiry-Based Learning and problem-solving are central to any Math Circle. However, circles can come in a number of varieties. Some emphasize preparation for mathematical competitions, some feel more like a

traditional enrichment class, without exams. Others take a more informal approach, with the learning occurring through games, stories, or hands-on activities.

It is this last type of circle that is particular suited to adapting to the MLA setting. We will discuss the particulars of using Math Circle philosophies and materials in an MLA course. (Received September 25, 2012)

1086-R1-2934 **E Lee May*** (elmay@salisbury.edu), MATH/COSC, Salisbury University, Salisbury, MD 21801. *"Statistics through Baseball": The Moore Method in Liberal-Arts Mathematics.*

This presentation will consist of an account of my experiences in teaching a liberal-arts mathematics course with the above title. The topics covered will include a history and description of the course; specifics on the degree to which the Moore Method of inquiry-based learning is practiced in it; a sample of student comments on the course; and my own evaluation, including successes and failures that I have experienced. Some knowledge of at least one of statistics and baseball is a sufficient but not necessary condition for gleaning some value from the talk. (Received September 26, 2012)

Using Mobile Communication Devices for Mathematics Education

1086-R5-1275 **Ashok K Deb*** (ashok.deb@usma.edu), 646 Swift Road, West Point, NY 10996, and **Kevin Blane** (kevin.blaine@usma.edu), 646 Swift Road, West Point, NY 10996. *iCalculus for iPad.*

Given the rise of social media and mobile devices, the Army is looking at ways to leverage these technologies. There was an iPad study at the U.S. Military Academy that searched for best practices for teaching with iPads where all the students have iPads as well. I taught 3 sections of Differential Calculus and developed some best practices for incorporating the iPad and social media into the classroom. (Received September 25, 2012)

1086-R5-1352 **Larissa B Schroeder*** (schroeder@hartford.edu), University of Hartford, Department of Mathematics, 200 Bloomfield Ave., West Hartford, CT 06117, and **Mako Haruta, Jean McGivney-Burelle, Fei Xue and John Williams.** *iPads as a Collaborative Tool.* Preliminary report.

How can iPads be used as a collaborative tool? A recent internal technology grant provided mathematics faculty at the University of Hartford with sets of 10 iPads to be used by small groups of students in our Calculus courses. In this session, we will discuss how we used iPads, along with AppleTV and multiple projection units, to improve student engagement and collaboration in our courses. The technological and logistical hurdles associated with multiple iPad use and the preliminary results of student surveys about the use of iPads in the classroom will also be presented and discussed. (Received September 21, 2012)

1086-R5-1417 **Nora Franzova*** (nfranzova@langara.bc.ca). *Using Mobile Communication Devices in Math Courses for Future Elementary School Teachers.* Preliminary report.

Presentation will focus on several semesters of experience with using mobile devices in classes that prepare future elementary school teachers. Since many elementary school pupils are fully immersed in the digital world, several questions arise. Are our future teachers ready for them? Should they be? And how much should they be? Different tools (blogs, iPads, smart phones) were incorporated into the course requirements for our students with a goal to promote experiential (out of classroom) use of mathematics. With endlessly changing technology the process was left to take its own development in choosing the strategies that worked and that did not work. (Received September 21, 2012)

1086-R5-2339 **Lila F Roberts*** (lilaroberts@clayton.edu) and **David R Hill** (dh11001@temple.edu). *Math Demos on the Go.*

In the early 2000s, Demos with Positive Impact was developed as a collection of online instructional demonstrations for teaching mathematics. Over the years, the collection has continued to be a valuable resource for mathematics faculty and students. To support users in today's mobile climate, several of the demos have been adapted to embrace tablet devices. This session will present several of these web-based adaptations which utilize HTML5 and Javascript utilities for mathematical display and interactivity. (Received September 25, 2012)

1086-R5-2485 **Lawrence C. Moore*** (lang@math.duke.edu), 2116 W. Club Blvd., Durham, NC 27705-3212, and **David A. Smith**. *Sage Interacts in an Online Calculus Text*.

The online textbook, Calculus: Modeling and Application, 2nd edition, published by MAA, is being adapted for the iPad. This talk will discuss and demonstrate the use of Sage interacts to replace commercial computer algebra systems in the text. (Received September 25, 2012)

1086-R5-2868 **Ahlam E Tannouri*** (ahlam.tannouri@morgan.edu), Mathematics Department, Carnegie Building, 1700 E. Cold Spring, Baltimore, MD 21251, and **Sam Tannouri** (sam.tannouri@morgan.edu), Computer Science Department, Calloway Building, 1700 E. Cold Spring, Baltimore, MD 21215. *Can my smart phone be a substitute to my office hours?* Preliminary report.

The advent of the new technology has revolutionized the options available to instructors and students; the modes of delivery can offer new possibilities that might facilitate cooperative learning for the enrichment of the mathematical experience. we will share our experience of using the wireless communication to help students remotely with their assignment in order to engage the students and enhance the learning process. we will reflect on the effectiveness and the drawback of these innovative tools that we are incorporating into our teaching. we will additionally share examples of the modules developed using these technologies to offer further insight into promising practices in this innovative education environment. (Received September 25, 2012)

1086-R5-2874 **Cynthia M. Traub*** (cytraub@siue.edu), Dept. of Math and Statistics, Campus Box 1653, Edwardsville, IL 62026. *Teaching College Algebra via the iPad*.

In Fall 2012, SIUE ran a pilot course to engage students in the material of college algebra via the medium of the iPad 2. Twenty four students were issued school-owned devices on the first day of class, theirs to keep for the semester as a tool by which they would learn algebra. This talk is their tale. We share what worked, what didn't, and why we feel this is a risk worth continuing to take. Along the way, we offer a review of apps that proved useful in practice, as well as tips for implementing a 1-1 iPad math classroom. (Received September 25, 2012)

1086-R5-2906 **Ben Galluzzo*** (bjgalluzzo@ship.edu), Department of Mathematics, 1871 Old Main Drive, Shippensburg, PA 17257. *Mobile Math Modeling Labs*.

Many real-world applications of mathematics require the use of tools not often found in the standard classroom in order to search for information, manage data, solve problems and communicate findings. Mobile communication devices allow students to move beyond standard data acquisition methods and provide means for entire classes to engage in all aspects of real world problem solving. In this talk we will discuss curriculum based projects for introductory college mathematics courses (including College Algebra, Precalculus, and Applied Calculus) in which students use mobile communication devices to actively participate in experiments, collect data, and analyze results – all within one class period. (Received September 26, 2012)

Writing the History of the MAA

1086-S1-317 **Bonnie Gold*** (bgold@monmouth.edu). *The Early History of POMSIGMAA*.

POMSIGMAA, the Special Interest Group of the MAA for the Philosophy of Mathematics, was approved by the Executive Committee of the MAA in 2002. I was one of the founding members and the primary force behind the organization of the SIGMAA, and have been involved in it since its inception. I will discuss the founding of POMSIGMAA and its governance and activities to date, as well as how it fits with the MAA's mission. (Received August 20, 2012)

1086-S1-407 **Agnes M. Kalemari*** (akalemari@optonline.net), Dept of Mathematics, 2350 Broadhollow Road, Farmingdale, NY 11735-1021. *Leading Players and Supporting Cast*. Preliminary report.

How many of the leaders of the New York Metro Section of the MAA have been household names (math households, that is)? Who were part of the rank and file? This "chapter" of our history will highlight some of those who worked so hard to found the section and/or to ensure its continued existence. (Hint: DES and MPD will be included.) (Received August 29, 2012)

- 1086-S1-819 **Timothy W Flood*** (tflood@pittstate.edu), Pittsburg State University, Department of Mathematics, 1701 S Broadway, Pittsburg, KS 66762. *The History of the Officers of the Kansas Section*. Preliminary report.

The officers of the Kansas section have come from a variety of different types of institutions from within the section. In addition, women have held key leadership roles throughout the long history of the section. Demographic information of the officers will be presented along with an analysis of the evolution of the section throughout the years. (Received September 13, 2012)

- 1086-S1-972 **James R Choike*** (choike@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Writing a History of the OK-AR MAA Section*.

Records, informally passed down over the years to various Secretary-Treasurers of the Oklahoma-Arkansas (OK-AR) section of the Mathematical Association of America (MAA), indicated that the 1988 spring meeting was the 50th annual meeting of this MAA section. At the spring 1987 OK-AR section meeting, in anticipation of celebrating this auspicious anniversary, I was drafted to write a history of the first 50 years of the OK-AR section of the MAA. In this session, I want to share this experience through the following goals: (1) present a simple outline which can be used to put together a section history; (2) identify resources that I found useful in writing an OK-AR section history; (3) offer tips for "digging deeper" into the history of an MAA section; (4) highlight reasons why writing a history of an MAA section provides a strong local historical confirmation of the importance of the MAA in fostering, in its original intent, "a more organized and continuing concern for collegiate mathematics," which, in 1915, the year the MAA was founded, was "the large field between the fields of secondary school mathematics and the field of pure research"; and (5) share highlights of the first 50 years of the Oklahoma-Arkansas section, as it approaches its 75th anniversary 2013. (Received September 17, 2012)

- 1086-S1-1318 **Daniel J. Curtin*** (curtin@nku.edu), Northern Kentucky University, Department of Mathematics and Statistics, Highland Heights, KY 41099. *The Kentucky Section of the MAA: 1917-2013*.

The Mathematics Section of the Association of Kentucky Colleges and Universities was founded in 1909. In May 1916 it was decided to apply to become a Section of the new MAA. This admission was accepted in February of 1917 and the first meeting of the new Kentucky section was held at Berea College that May. Since then the section has been very active- with annual spring meetings and rare fall meetings. Speakers have come from both private and public institutions, and many nationally known mathematicians have given invited addresses. Women have been very active. Elizabeth LeSturgeon was Chairman in 1923 and our second section governor was Aughtum Howard in 1951. There has also been active participation by African-American mathematicians. In the late 1930s several Jewish mathematicians found refuge in Kentucky and participated in section meetings. Mathematicians of all types have given talks and participated in panels throughout the history of the section. (Received September 21, 2012)

- 1086-S1-1446 **J Michael Pearson*** (pearson@maa.org), 1529 18th St NW, Washington, DC 20036. *CUPM: The History of an Idea*.

Since the founding of the MAA in 1915, undergraduate mathematics has since the beginning been both our focus and our strength. The Committee on the Undergraduate Program in Mathematics leads MAA was established by a December 1952 vote of the Board of Governors; the title of this talk is borrowed from an article by W. L. Duren, Jr., in the 1967 special issue of the American Mathematical Monthly celebrating the 50th anniversary of the MAA.

While MAA has always recognized the diverse goals for undergraduate mathematics, and the work of CUPM challenges us to respond to a dynamic educational landscape in which mathematics continues to play a central role. CUPM plans to release a revised Curriculum Guide in time for our centennial year; here we'll look back to see how current efforts grow naturally from our history. (Received September 22, 2012)

- 1086-S1-1616 **V Frederick Rickey*** (fred.rickey@me.com) and **Victor J Katz** (vkatz@udc.edu). *The History and Impact of IHMT, the Institute in the History of Mathematics and its Use in Teaching*.

An NSF proposal for an "Institute in the History of Mathematics and Its Use in Teaching" was submitted under the auspices of the MAA, where the co-directors were visiting mathematicians in 1993-94 and 1994-95 respectively. The Institute strove to aid college faculty in teaching courses in the history of mathematics and in using the history of mathematics in the classroom to motivate students. Forty participants came for three weeks during the summers of 1995 and 1996; an additional forty attended in 1996 and 1997. A new group of forty attended for two weeks in the summers of 1998 and 1999. The faculty for this Institute consisted of

distinguished historians of mathematics. While the institute was designed to improve the teaching of the history of mathematics and show faculty how to use history in teaching mathematics classes, there was one result that surprised the co-directors: A considerable number of the participants became so interested that they started doing research in the history of mathematics. We will describe the structure, content, and results of IHMT and discuss its substantial impact, both on the careers of the individuals involved and on the teaching and use of the history of mathematics in colleges and universities throughout the country. (Received September 23, 2012)

1086-S1-1935 **Leon M Hall*** (lmhall@mst.edu), Department of Mathematics and Statistics, 400 W. 12th Street, Rolla, MO 65409-0020. *The Last Quarter-Century in the Missouri Section.* Preliminary report.

This talk will give an overview of the programs, activities, people and institutions active in the Missouri Section since 1985. The future of the section will also be discussed. (Received September 24, 2012)

1086-S1-2443 **Caren Diefenderfer*** (cdiefenderfer@hollins.edu) and **Elizabeth Mayfield.** *Digging up More History in the Capital Section.* Preliminary report.

The Maryland-District of Columbia-Virginia Section has formed a committee to write our Section's history in anticipation of the MAA Centennial. At JMM 2012 Betty Mayfield and Jon Scott talked about the interesting documents we had found, often rescued from the basements of past Section officers. At our spring 2012 meeting Caren Diefenderfer interviewed and videotaped several long time section members to record their impressions of people, places, and events that have been important to our section. We are encouraging section members to use our website for blogging about the section's history. This talk will describe these recent efforts to record our history. (Received September 25, 2012)

General Session on Assessment and Outreach

1086-VA-624 **Karen Traxler*** (karen.traxler@unco.edu) and **Soofia Malik.** *Assessing the Reliability and Precision of the Visual Analog and Likert Response Scales in a Measurement of Statistical Anxiety in Undergraduate Students.*

Response scale selection is a critical aspect of survey development. Two prevalent response scales in survey research are the Likert Scale and the Visual Analog Scale (VAS). In the medical field, the VAS is routinely used to measure levels of pain, disability, and anxiety. (Avery, 2010; and Morris et al., 2005). Researchers in mathematics education have been reluctant to employ VAS over the more widely accepted Likert rating scales; due in part to the many decisions necessary in the development of VAS, such as: line placement, length, or absence, anchor characteristics, and discrete vs. continuous scales (Couper, Tourangeau, Conrad, & Singer, 2006). In order to provide recommendations to researchers in mathematics education, the current study assessed the reliability and precision of scores derived from a 5-point Likert scale and VAS on a 10-item statistics anxiety survey. The participants were 400 undergraduate students at a university in the midwest United States. Results suggested that reliability coefficients were moderate to high, $r = .66$ to $r = .91$, with no indication of age or gender differences. The increased precision of measurement with the VAS provides evidence to recommend their use in future measurements of mathematical attitudes, beliefs, and opinions. (Received September 09, 2012)

1086-VA-1198 **Josaphat A. Uvah*** (juvah@uwf.edu), Department of Mathematics & Statistics, University of West Florida, 11000 University Parkway, Pensacola, FL 32514, and **Kuiyuan Li** (kli@uwf.edu), Department of Mathematics & Statistics, University of West Florida, 11000 University Parkway, Pensacola, FL 32514. *An Assessment of Math Proficiency Among High School Students Using the AMC Tests.*

In this study, we assess the group performance of 970 high school students in mathematics. We use data from The American Mathematics Competitions tests administered at the University of West Florida for five years, 2007-2011, to assess the proficiency level of the participants as a group. We identify areas of strength and weaknesses in high school mathematics for the group. Furthermore, we assess the college readiness of the students in the area of mathematics. Aside from identifying some factors known to affect students' performance at the high school levels, we offer suggestions on individual and institutional remedies that could be implemented in the 11th and 12th grades in preparation for study in institutions of higher learning. Results of our study could be used to advise grade teachers on the topics that they should emphasize at the various high school grade levels. (Received September 20, 2012)

1086-VA-2664 **John Gruver*** (jgruver@ucsd.edu), 6475 Alvarado Road, Suite 206, San Diego, CA 92129. *The Danger of Narrow Calculus Assessments and How to Broaden Them.*

In this presentation I argue narrow Calculus assessments should be broadened to test for mathematical proficiency. Narrow tests can dangerously provide an illusion of competence to instructors and misrepresent mathematics to students. Flexer (1991) showed that students who had a high stakes exam at the end of the year did well on the problem “ $87 - 24$ ” (83% correct), but did poorly on “subtract 24 from 87” (only 66% correct). A control district with no high stakes exam did similarly on both items (77% correctly and 73% correctly respectively). This suggests repeated practice of a particular problem type leads to greater mastery of that type, but the competence is highly contextualized. Also, students take cues from assessments about what to study. If students are only given problems that require predictable computations, they may begin to think Calculus is only about computing. In order to avoid these problems, we must give our students balanced assessments that test for mathematical proficiency. In this presentation, I will show how the NRC’s (2001) definition of mathematical proficiency can be used to critically analyze assessments. Also, I will show examples of items, which could appear on a balanced assessment. (Received September 25, 2012)

1086-VA-2756 **Jalalidin Jaenbai*** (jaenbai@yahoo.com), Claremore, OK. *Using fuzzy logic methods for assessing student learning outcome in a mathematics course.*

We will discuss about the vague nature of student learning outcomes and show how methods of fuzzy logic can be used to represent impreciseness of assessment criteria in an undergraduate mathematics course. (Received September 25, 2012)

1086-VA-2767 **Frederick A. Adkins*** (fadkins@iup.edu), Mathematics Department, Indiana University of Pennsylvania, Indiana, PA 15705, and **Yu-Ju Kuo** (yjkuo@iup.edu), Mathematics Department, Indiana University of Pennsylvania, Indiana, PA 15705. *Mentoring Mathematics and Science Majors in Applying Mathematics.*

The activities, experiences, and results from creating a blended math and science cohort of upper-level undergraduates and graduate students in the M.S. in Applied Mathematics program are summarized. In the third year of funding from the National Science Foundation’s Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM), our program has expanded recruitment, improved retention, and further developed student skills. Scholarship program activities establish a supportive connection of master’s students with undergraduates. Science majors take additional coursework towards a minor or double major in mathematics. The scholarship cohort participates in interdisciplinary activities, investigates careers and graduate schools, communicates with external mentors, meets with invited speakers, and attends professional development workshops on use of mathematical software and technology. Many sponsored events are open to the community and positively impact the local academic culture. In addition to presenting activities and outcomes, suggestions for enhancing program impact will be included. On assessments, students report improved satisfaction with the academic environment, their selected majors, and their career plans. (Received September 25, 2012)

General Session on Calculus

1086-VB-36 **Steve M. Anglin, Ph.D. (h.c.), Sc.M.*** (stevemanglin@yahoo.com), PO Box 1291, Mt. View, CA 94042. *Learning the Chain Rule Using the DOTI Method.*

For composite functions $f(x)$ and $g(x)$, the derivative is the chain rule, a chain of derivatives on g , then f . Well, a new way of learning and thinking of the Chain Rule is as follows: Similar to learning how to multiply/factor 2 binomials using the FOIL Method, I hereby propose the DOTI (Differentiate “Outside” To “Inside”) Method as a way of best describing/learning the Chain Rule for taking the derivative of two or more composite functions, f , g and maybe an h and even more functions. (Received June 10, 2012)

1086-VB-398 **Alison Ahlgren*** (aahlgren@illinois.edu), Department of Mathematics, 1409 West Green Street, Urbana, IL 61801, and **Marc Harper** (marcharper@ucla.edu). *The Impact of Arithmetic Skills on Success in Calculus II and III.* Preliminary report.

We discuss correlations between failure in traditional second semester and multivariate calculus courses with a lack of basic arithmetical skills, indicated by performance on an ALEKS assessment. In particular, we will discuss the relationship between initial arithmetic performance measured in terms of skills from precalculus and earlier subjects (no calculus) and final course grades for approximately 1000 students for two years with data derived from the placement program at the University of Illinois. We will also discuss specific items/skills for which the lack of is highly correlated with course failure. (Received August 29, 2012)

1086-VB-627 **Jun Tao*** (jtao68@yahoo.com), 14207 Eagle Mine Drive, Poway, CA 92064. *The Development of the Fundamental Theorem of Calculus by Using the Limit Approach Only.*

This paper describes how to develop the Fundamental Theorem of Calculus by only using the limit approach. Let $F(x)$ be differentiable and $f(x)$ be continuous on an interval $[a, b]$, where $F'(x) = f(x)$. Let's divide the interval $[a, b]$ into n pieces of small intervals whose width is h ($h = \frac{b-a}{n}$); then the following formula can be directly proved by using the limit approach:

$$\lim_{n \rightarrow \infty} [F'(a)h + F'(a+h)h + \cdots + F'(a+(n-1)h)h] = F(b) - F(a)$$

Since $f(x) = F'(x)$, we have $f(a)h = F'(a)h, \dots, f(a+(n-1)h)h = F'(a+(n-1)h)h$. Let's substitute them into the proved formula, we have:

$$\lim_{n \rightarrow \infty} [f(a)h + f(a+h)h + \cdots + f(a+(n-1)h)h] = F(b) - F(a)$$

Rewrite the formula as:

$$\int_a^b f(x) dx = F(b) - F(a)$$

(Received September 21, 2012)

1086-VB-687 **Mara Aruguete** (aruguetem@lincolnu.edu), 701 S Providence Road, Apt 1I, Columbia, MO 65203, and **Chelsey Stephenson*** (rocking_girlz@hotmail.com), 179 County road 420, Linn, MO 65051. *Convexity Conditions of Euler-Lagrange Equations in Optimization Problems.*

In this presentation, we will mainly talk about the convexity conditions of Euler-Lagrange equations in optimization problems. Value functions with optimal control is also examined through the feedback rules, Hamilton-Jacob theory. (Received September 11, 2012)

1086-VB-1011 **David Dwyer** (dd4@evansville.edu), 1800 Lincoln Ave, Evansville, IN 47722, **Mark Gruenwald** (mg3@evansville.edu), 1800 Lincoln Ave, Evansville, IN 47722, **Michael Axtell** (axte2004@stthomas.edu), 2115 Summit Ave, St. Paul, MN 55105, **Nicholas Baeth** (baeth@ucmo.edu), PO Box 800, Warrensburg, MO 64093, **Kenneth Luther** (ken.luther@valpo.edu), 1700 Chapel Dr, Valparaiso, IN 46383, and **Joe Stickles*** (jstickles@millikin.edu), 1184 W Main St, Decatur, IL 62522. *Resequencing Calculus: An Early Multivariate Approach.*

The Resequencing Calculus project is redesigning the calculus sequence, ordering topics so that material prerequisite for upper-level STEM courses is front-loaded into the first two semesters and so that there is a natural progression of difficulty throughout the 3-course sequence. This is done by introducing multivariate calculus in Calculus 2 and moving infinite series to Calculus 3. As a result, Calculus 1 and 2 form a strong 2-course sequence for students in the life sciences, economics, and chemistry, all of whom are likely to encounter multi-variable models in later courses. Moreover, students successful in Calculus 2 may enter directly into not only Calculus 3, but also differential equations, linear algebra, or calculus-based probability. The restructuring eases time pressure in Calculus 3, thus facilitating a thorough treatment of vector calculus through Stokes' Theorem and the Divergence Theorem while maintaining a rigorous treatment of the material. We will discuss the progress and assessment of the project to date, future plans, and various approaches for dealing with multiple challenges, including those posed by course transfers and AP credit. This project is supported by NSF Grants DUE 1225566 and 0836676. Details can be found at <http://www.resequencingcalculus.com>. (Received September 17, 2012)

1086-VB-1433 **Daniel C. Kemp*** (dan.kemp@sdsu.edu), Mathematics and Statistics Department, South Dakota State University, Box 2220, Brookings, SD 57007-1297. *A project to evaluate the probability integral using Calculus II techniques.*

The fact that the probability integral can be evaluated using only Calculus II techniques is well known in the sense that there are numerous publications illustrating this that date back to Stieltjes in 1918. However these evaluations are not well known enough to appear in calculus text books. This talk will present a project that has been successfully used with second semester freshmen in Calculus II to evaluate the probability integral. The main skills needed are integration by parts and mathematical induction. Part of the project will establish Wallis' product formula for $\pi/2$ which is needed to complete the main idea due to Thomas Stieltjes. (Received September 21, 2012)

1086-VB-2156 **Chad Awtrey*** (cawtre@elon.edu). *Writing to learn in first semester calculus.*

The research literature suggests that if students engage with a "Writing to Learn" (WTL) pedagogy, they will experience improved attitudes, deeper conceptual understanding, less rote memorization, and increased problem solving ability. In this talk, we discuss helpful resources for incorporating WTL activities in mathematics courses,

sample writing activities from a first-semester calculus course, and (multiple drafts of) student work. (Received September 24, 2012)

1086-VB-2293 **Dov Zakis*** (zakis@gmail.com). *The Effects of GSP-Based Applets on Students' Understanding of Graphical Calculus Concepts.*

Calculus students' resistance to and difficulties with graphical approaches to calculus are well documented in the mathematics education literature. This is particularly concerning because many educators and education researchers regard reasoning with visual representations to be an essential component of gaining an understanding of calculus that goes beyond symbol-pushing. I will present a series of Geometers Sketchpad-based applets and accompanying activities that were used as part of a technologically enriched Calculus I course. Videotapes of individual student problem-solving interviews and in-class group activities reveal that these activities had profound effects on students' approaches to and dispositions regarding calculus problems. These applets were not simply disposable crutches used to learn; they became mental objects students could think with and facilitated a diverse range of student approaches to graphing and non-graphing problems. I will describe these varied student approaches and the student reasoning that accompanied them as related to the concept of derivative. (Received September 25, 2012)

1086-VB-2394 **Dragan Jankovic*** (draganj@cameron.edu), Cameron University, Department of Mathematical Sciences, 2800 W Gore Blvd., Lawton, OK 73505. *New Curves from Old via Tangents.* Preliminary report.

Let $f(x)$ and $g(x)$ be smooth real functions on an interval (a, b) with $g'(x) \neq 0$. It is a simple exercise to show that the tangent lines to the curves in the family $f(x) + kg(x)$ (k is a real number) at $x = t$ are concurrent and that the point of intersection lies on the curve $x = x - \frac{g(t)}{g'(t)}$, $y = f(t) - \frac{f'(t)g(t)}{g'(t)}$, where t varies in (a, b) . Some well known curves are produced by this construction. For instance, $g(x) = x - \frac{1}{x}$, ($0 < x < 1$), and $f(x) = -\ln(x)$ generate the tractrix, while $g(x) = \tan(\frac{x}{2})$ ($0 < x < \pi$) and $f(x) = -x \tan(\frac{x}{2})$ generate the cycloid. (Received September 25, 2012)

1086-VB-2400 **Samantha N Andrews*** (sandrews@gatech.edu), 791 Atlantic Drive/MiRC, Atlanta, GA 30332, and **Greg Mayer, Nathaniel Tindall, Daniel Connelly and Rui Hu.** *Development of an Online Multivariable Calculus Course for High School Students.* Preliminary report.

In this talk we will describe the development of a one semester online multivariable calculus course, with an engineering applications, for high school students that have completed AP Calculus BC. Particular challenges that were faced in the development process include the alignment of the Mathematics Common Core Standards for a two semester course to a one semester course, the inability to administer proctored exams, and a development timeline of only five months. These challenges were addressed through 1) the development of a problem based learning group project, 2) writing assessments that have students connect engineering to calculus concepts, 3) the use of open educational resources, and 4) the use of technologies and processes that enabled collaborative authoring, editing, and sharing of course materials and resources. As the course will be first offered in January 2013, how the researchers intend to evaluate the delivery of the course will also be discussed. (Received September 25, 2012)

1086-VB-2411 **Mitsuo Kobayashi*** (mkobayashi@csupomona.edu), Cal Poly Pomona, Department of Mathematics and Statistics, 3801 West Temple Avenue, Pomona, CA 91768. *A Dissection Proof of Leibniz's Series for $\pi/4$.*

Inspired by Lord Brouncker's discovery of his series for $\ln 2$ by mapping rectangular areas below the curve $1/x$, Viggo Brun found a way to partition regions of the unit circle so that their areas correspond to terms of Leibniz's series for $\pi/4$. Brun's argument involves splitting the circle into triangular wedges and applying a limiting process. We show that usual techniques in calculus may be used to derive a result similar to Brun's. (Received September 25, 2012)

1086-VB-2729 **Dylan W Helliwell*** (helliwed@seattleu.edu), Department of Mathematics, Seattle University, 901 12th Avenue, P.O. Box 222000, Seattle, WA 98122-1090. *Oral Reviews in Calculus.*

Oral reviews are hour-long, ungraded opportunities for students, working with faculty or advanced students, to negotiate meaning, make conceptual connections, discuss why procedures work, and draw representations that make concepts clearer. Incorporating oral reviews into calculus classes has proven to significantly improve student performance. In this talk, we'll look in more detail at what oral reviews are, see how they have been implemented, and give evidence of their benefit to students. (Received September 25, 2012)

- 1086-VB-2779 **Janine M. Haugh*** (jhaugh@unca.edu), University of North Carolina at Asheville, 1 University Heights, CPO #2350, Asheville, NC 28804. *Restructuring Calculus 2, Inside-Out and Backwards*. Preliminary report.

The second semester in a traditional calculus sequence is often feared by undergraduate students. While the first semester tends to feel like an organized story from start to finish, Calculus 2 sometimes feels choppy, random, and disconnected. A few weeks before the start of the fall semester, Western Carolina University offered a workshop on integrative course redesign. As the only mathematician in attendance, I was skeptical in the beginning. By the end of the day, however, I was surrounded by colored paper, outlines, and a new storyline for this much-maligned course. In this talk I will discuss my experiences in the workshop, and my successes and failures from my first semester teaching this “new” course. (Received September 25, 2012)

- 1086-VB-2914 **Lipika Deka*** (ldeka@csumb.edu), 100 Campus Center, Seaside, CA 93955, and **Gabriela Stanica**. *Improving Calculus learning through Boot camp and Study Hall*. Preliminary report.

Calculus is a gatekeeper to entry into most STEM majors. Yet, it is considered one of the hardest courses for STEM majors at California State University-Monterey Bay (CSUMB). The pass rates have been discouraging for years. At CSUMB, three primary reasons for failure for students stand out: poor preparation, lack of study skills and lack of student engagement. The students struggle so much with the lack of necessary skill sets that they fail to learn the beauty of Calculus. The class time is not sufficient to support the students with the poor skill sets along with covering the heavy syllabus. To solve this problem we introduced two types of supplementary workshops, called Boot Camp and Study Hall, which are facilitated by the instructors themselves with the support of tutors. After two semesters of using these workshops we see a big difference in students learning and engagement. In addition, these workshops build a sense of community among the instructors, tutors and the students that helped to improve student engagement. This talk will discuss the details of what these workshops are and talk about the successes and the challenges they faced. (Received September 26, 2012)

- 1086-VB-2962 **Paul Sisson*** (paul.sisson@lsus.edu), 1372 Leonard Road, Shreveport, LA 71115. *What it takes for a student today to be successful in calculus?*

Ever-changing methods of calculus instruction and curriculum influence students and instructors alike. While instructors need to adapt to new ways of teaching, students also need to adjust the way they learn the material in order to reach their fullest potential. We know when it comes to mathematics education, students learn best by doing. Physically taking the time to write out problems and working through their solutions is key. Nowadays, technology is being incorporated in and out of the classroom more than ever before. As the calculus curriculum evolves and technology becomes more prominent in instruction, we can focus on motivating our students through topics such as Applications of Integrals and Taylor Series. By pointing out their various applications within sciences and engineering, we can help students relate calculus to other topics of interest. As a former professor, Dr. Paul Sisson now serves at Provost and Interim Chancellor at Louisiana State University in Shreveport. He carries with him firsthand knowledge and experience to influence mathematics instructors from the perspective of a professor, administrator, and author. (Received September 26, 2012)

General Session on the History and Philosophy of Mathematics

- 1086-VC-1371 **Lee Stemkoski*** (stemkoski@adelphi.edu), Dept. of Math and Comp. Sci., 211 Post Hall, Adelphi University, 1 South Ave., Garden City, NY 11530. *The work of Leonhard Euler related to Fermat's Last Theorem*.

Leonhard Euler is credited as having solved Fermat's Last Theorem for the case where the exponent is 3. However, the proof as presented in Euler's *Algebra* of 1770 contains a step which, although correct, is not justified. Historians nonetheless credit Euler with the proof, often referencing an earlier paper (*Supplementum quorundam...*, published 1760) where calculations appear that could be used to provide an alternative proof of the unjustified step in Euler's *Algebra*. We present a translation of this earlier paper and discuss the results related to Fermat's Last Theorem, as well as the possibility that Euler had worked on an alternative proof of Fermat's Last Theorem (for exponent 3), based on references in his correspondence with Goldbach. (Received September 21, 2012)

- 1086-VC-1768 **Robert E. Bradley*** (bradley@adelphi.edu), Adelphi University, Dept. of Mathematics & Computer Science, Garden City, NY 11530. *L'Hôpital's Geometric Exposition of the Calculus*.

In the early 1690's only a handful of people were conversant with Leibniz' differential calculus. That all changed in 1696 when the Marquis de l'Hôpital published *Analyse des infiniment petits*, the first calculus textbook. His exposition, based on lessons that he had been given by Johann Bernoulli, is very different from the way calculus has been explained since the mid-19th century. In this talk, we will consider l'Hôpital's way of determining the tangents of various classical curves from their geometric properties, without making direct use of their equations. (Received September 24, 2012)

- 1086-VC-1875 **G. Arthur Mihram*** (dmihram@usc.edu), P.O. Box No. 1188, Princeton, NJ 08542-1188, and **Danielle Mihram** (dmihram@usc.edu), Univ Sthrn Calif, LVL 113, MC 2571, Los Angeles, CA 90089-2571. *A Natural Philosophical Connexion Relating Mathematics, Science, and Progress*. Preliminary report.

Quinn concludes [AMS NOTICES 59(1): 31 (2012)] that our mathematics is not science, the criterion for validity (truthfulness) differing: Science requires comparison (of the 'model') with external events; mathematics is internal. Whether mathematics progresses over time, whereas philosophy so falters, can be considerably resolved by recalling that natural philosophy (properly conducted: cf. Cotes's Preface, Newton's PHILOSOPHIAE NATURALIS PRINCIPIA MATHEMATICA, ed2, ca1713) is the foundation of Modern Science [= that human activity devoted to the search for the very explanation for (i.e., for the truth about) any particular naturally occurring phenomenon]: Any natural philosopher must begin by observing Nature before modeling it [cf. TEOREMA 28(2): 35 (2009)]. Mathematician/science-historian Sarton concluded that the only true human progress results from science because of its dedication to finding truth(s). Our mathematics is not science, deals not with Nature, but rather with abstractions (points, lines): thus, mathematics is not itself sufficient for Science [LT More (Dean, Univ Cincinnati) LIMITATIONS OF SCIENCE, 1915: 151]. Also, mathematics is not necessary for Science (Darwin). Yet, we conclude that both mathematics and (natural) philosophy do provide human progress. (Received September 24, 2012)

- 1086-VC-1913 **Richard Stout*** (richard.stout@gordon.edu), Department of Mathematics, Gordon College, Wenham, MA 01984. *Reforming Mathematics at Cambridge: George Peacock and the Tripos Exam*.

Throughout the nineteenth century the Tripos exam played a significant role in mathematics education at Cambridge University. In the early part of the century, mathematics at Cambridge was somewhat stagnant and uninspiring, until the Analytical Society, a student-led group formed in 1812, started the discussion about initiating much needed reform. Among the leaders of that group was the mathematician George Peacock, who went on to have a distinguished career at the university and later served as the Dean of Ely Cathedral. As a young faculty member Peacock realized that changes in the Tripos exam would make a significant contribution toward reforming mathematics at Cambridge and took on the challenge. In this talk we will consider the importance of this exam in Cambridge mathematics, Peacock's role in making changes to the exam, and how his work helped bring about reforms in the British mathematical community. (Received September 24, 2012)

- 1086-VC-2301 **Mariah Birgen*** (mariah.birgen@wartburg.edu), Science Center, 100 Wartburg Blvd., Waverly, IA 50677. *The Historical Roots of Math and Physics in the British Isles : A Tour*.

In May 2012, I had the opportunity to take 10 students on a 3.5 week class where we were Mathematical tourists in the British Isles. In this presentation I will divulge all my secrets including how I planned the trip, where we went, what we learned, and probably most importantly, what I will do differently next time.

Teaching at a Liberal Arts college offers some wonderful opportunities for faculty. When one of my colleagues retired, I took over his course which involved traveling with students to various museums, libraries, and important historical sites throughout the British Isles. The course counts for general education requirements of diversity and writing intensive for the students who pay for the extra costs as a course fee. We flew in and out of London, traveled nearly exclusively by train, stayed in hostels, and visited England, Scotland, Wales and Ireland. The oldest mathematician studied was Napier and the youngest was Turing. (Received September 25, 2012)

General Session on Interdisciplinary Topics

- 1086-VD-329 **Mary Therese Padberg***, The University of Iowa, 14 MacLean Hall, Iowa City, IA 52242, and **Isabel Darcy, Stefan Giovan, Stephen Levene and Rob Scharein**. *The Twisted Tale of Protein-Bound DNA*. Preliminary report.

Knowing how DNA interacts with proteins is vital for understanding basic biological functions such as replication and transcription. Thus, discovering the shape that DNA conforms to when bound by proteins (protein-bound DNA) is an important topic. Geometric structures for some protein-bound DNA complexes can be found using laboratory techniques. For most complexes, however, these techniques often fail. When this happens we can experimentally determine the general shape of the complex, or its topology (e.g. a square and a circle represent the same topological object because you can deform one into the other without introducing any breaks). Since two things can be vastly different geometrically but have the same topology, we cannot rely on topology alone. In order to understand the structure of protein-bound DNA at a scientifically useful level we need to know its geometry. In this talk we discuss how to geometrically describe the structure of DNA. We introduce preliminary software which can be used to determine likely geometries consistent with known protein-bound DNA topologies. We will discuss the flexibility of this software to accept user modifications in order to model the complex under variable conditions. This talk is aimed toward a general audience. (Received August 21, 2012)

- 1086-VD-478 **Lori Koban***, lori.koban@maine.edu, and **Jordan LeGrand and Joshua Case**. *Counting Pitch Class Sets with Burnside's Lemma*. Preliminary report.

Mathematical tools from Combinatorics and Abstract Algebra have been used to study a variety of musical structures. One question asked by music theorists is: How many d -note diatonic pitch class sets exist in a c -note chromatic universe? In the music theory literature, this question is answered with the use of Pólya's Enumeration Theorem. We solve the problem using simpler techniques, including only Burnside's Lemma and basic results from Combinatorics and Abstract Algebra. We use intervals arrays that are associated with pitch class sets as a tool for counting. (Received September 04, 2012)

- 1086-VD-1588 **Yuesheng Xu and Liang Zhao*** (lzhao04@syr.edu), Carnegie 215, Syracuse University, Syracuse, NY 13210. *Filter-Based Multiscale Entropy Analysis of Complex Physiologic Time Series*.

The multiscale entropy analysis has been widely used to analyze the complexity of physiologic time series, such as heart rate. To better capture the multiscale information from different physiologic time series, we introduce a filter-based multiscale entropy method providing more flexibility to study the complexity of a given time series carried at different scales. The original time series is passed through desired fine-to-coarse filters at different scales and an entropy value is calculated at each scale according to the structure of the filtered time series. We apply it to the human heartbeat interval time series with piecewise linear filter motivated by the heart rate turbulence theory. The results on different length of data consistently indicate the loss of complexity with aging and some pathologic conditions. We find that aging may reduce the complexity of the cardiac system more than some certain diseases. Moreover, the results also separate healthy and pathologic groups very well, suggesting diagnostic uses. (Received September 23, 2012)

- 1086-VD-1595 **Amalia Rusu** (arusu@fairfield.edu) and **Stephen B Mislich*** (200906004@panthers.greenville.edu), 315 E. College Avenue, Greenville, IL 62246-1145, and **Lukas Missik** (lukasmisik@college.harvard.edu) and **Benjamin Schenker** (schenk@cooper.edu). *Cyber Security with Handwritten CAPTCHA*.

Protecting resources in cyberspace from unauthorized access by machines is critical. A reverse version of Alan Turing's test, with the machine acting as the judge, called CAPTCHA (Completely Automatic Public Turing test to tell Computers and Humans Apart), is currently used in Cyber security. Most of the CAPTCHAs in commercial use take advantage of superior human ability in reading machine printed text with others exploiting the gap in facial recognition, image understanding and object identification. However, many are proven vulnerable or have been broken. Since automated recognition of unconstrained handwriting continues to be challenging for the optical character recognition systems, handwriting recognition is a better alternative for CAPTCHA. We present handwritten CAPTCHA which features synthetically generated English handwriting that has been transformed according to specific principles of cognitive psychology. These transformations ensure that our CAPTCHAs are both easily interpretable by humans and unrecognizable by machines. Early testing results indicate that users are readily able to solve these CAPTCHAs due to Gestalt principles and Geon theory, while machines cannot currently make use of these cognitive aids, thus making them a viable solution for Cyber security. (Received September 23, 2012)

- 1086-VD-1996 **Sujin Kim*** (kims@savannahstate.edu) and **Deden Rukmana** (rukmanad@savannahstate.edu). *Interdisciplinary Research of Case Study in Low-Income Neighborhoods to Identify Risk Factors Contributing to Obesity*. Preliminary report.

This NIH-funded interdisciplinary study conducts survey with 65 questions to collect obesity data in six low-income neighborhoods in Savannah, Georgia so that we could establish local database. We will present an overview of the collected data from the survey and statistical analysis of the survey to find the prevalence of obesity among residents of low-income neighborhoods in Savannah which are correlated with contributing factors including lifestyle or behavior factors, individual factors, social factors and built environmental factors. We will also present in-class activities with the collected survey data to understand basic bio-statistics concepts and analysis. (Received September 24, 2012)

- 1086-VD-2297 **Haley A Yapple*** (haleyyapple@u.northwestern.edu). *Modeling the dynamics of competitive systems, with applications to religious shift and ferromagnetism*. Preliminary report.

When a society is partitioned into two groups, the dynamics of affiliation can be studied using mathematical models. We construct a model that captures mean-field behavior with a simple nonlinear differential equation. We then generalize to include the possibility of non-trivial interaction networks and allow for a discrete or continuous system. The resulting integro-differential equation is amenable to perturbative analysis and numerical simulation.

When applied to the case of religious shift in a society, our mean-field model is a good fit for historical census data. Perhaps surprisingly, our model is also a good fit for ferromagnetism, using an analogy between individuals in a society who may switch group affiliation and particles in a material that may switch magnetic polarity. Based on the energy arguments of the Ising model, we are able to reproduce results from statistical mechanics and make predictions about dynamics that are difficult or impossible to determine from stochastic systems. (Received September 25, 2012)

- 1086-VD-2555 **David M Gohlich** (david.gohlich@usma.edu), Thayer Hall Room 240, Building 601, West Point, NY 10996, **Christopher E Weld** (christopher.weld@usma.edu), Thayer Hall Room 240, Building 601, West Point, NY 10996, and **Gerald Kobylski*** (gerald.kobylski@usma.edu), Thayer Hall Room 240, Building 601, West Point, NY 10996. *Implementing an Institutional Interdisciplinary Program with Mathematicians at the Lead (a Follow-Up Report)*.

Many of tomorrow's problems will need to be solved using multiple academic disciplines. The solvers of these complex problems will need to utilize a variety of intellectual skills to understand, transform, and then determine solutions. To develop versatile problem solvers ready to confront the challenges of an increasingly complex world, West Point is implementing a more interdisciplinary approach to educating future Army leaders. Collaborating with other academic departments at West Point, faculty in our Mathematics Department have built and are currently implementing an energy theme into our mathematics curriculum, a curriculum that is a lead for approximately 15 of our general education courses. Our program challenges students to use not only what they learned in a single class, but what they learned across a variety of classes to solve increasing complex problems. Our discussion will be a follow-up to last year's report which focused on the planning of our interdisciplinary program. This discussion will now focus on the execution of the interdisciplinary program. (Received September 25, 2012)

- 1086-VD-2821 **Alexi Hoeft*** (hoefta@vcu.edu), Richmond, VA. *What would a map of mathematics look like?*

We exhibit a dynamic visual-spatial representation of mathematics as a city, with related areas of study shown as boroughs connected via the corresponding ground-breaking papers or theorems. Different layers of the map appeal to different demographics including mathematicians, students, and members of the general public. The goal of the map varies with the user. For mathematicians, we aim to make the connections amongst the areas of math easier to visualize and consequently encourage interdisciplinary research and communication. For student users, we aim to inspire and motivate the topics they see in the classroom by showing how they fit into the global picture of mathematics. And for the general public, the goal is to heighten awareness of what mathematics is by making it easier to learn about the mindset, structure, and overarching goals of mathematics, as well as the development of the main tools of the trade. (Received September 25, 2012)

- 1086-VD-2854 **David Lamp** (david.lamp@ttu.edu), Department of Physics, Lubbock, TX 79409, **Rebecca Ortiz** (rebecca.ortiz@ttu.edu), College of Education, Texas Tech University, Lubbock, TX 79409, **Magdalena Pando** (magdalena.pando@ttu.edu), College of Education, Texas Tech University, Lubbock, TX 79409, **G. Brock Williams** (brock.williams@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, and **M. Carol Williams*** (carol.williams@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *A Multidisciplinary Sciences Teacher Education Program.*

We will describe our three-track program for enhancing the mathematical and scientific knowledge of elementary, middle, and high school teachers. Participants take courses in math, physics, biology, chemistry, geosciences, and education. Most of the courses are taught online during the school year and face-to-face during the summer. Several of the courses are co-taught by faculty from math, science, and education. Participating teachers earn masters degrees in Multidisciplinary Sciences. (Received September 25, 2012)

General Session on Mathematics Education

- 1086-VE-33 **Daniel Huber, Leslie Jones*** (lbjones@ut.edu) and **Rebecca Waggett.** *The Geometric Analysis of Shark Teeth.* Preliminary report.

We present integrated curriculum ideas developed for teacher-training workshops for high school geometry teachers. We emphasize the importance of building inviting, relevant context for mathematical content. Our backdrop is the ocean, where geometry determines the feeding behavior and choice of prey for marine animals. The main characters in our talk are a couple of hungry sharks. The solution to each question posed makes use of a mathematical model. (Received June 05, 2012)

- 1086-VE-89 **Stanley Rothman*** (stanley.rothman@quinnipiac.edu), 15 Stacy Ct, Cheshire, CT 06410. *Sandlot Stats: Learning Statistics with Baseball.*

Believing that applying statistics to an area that a student both enjoys and understands will enhance learning, led me to create the course "Baseball and Statistics" in 2008. The course, using the book "Sandlot Stats", runs every semester as an elective for non-majors. Each student selects two players they want to statistically compare. At the end of the course each student presents a PowerPoint presentation comparing their two players. The course is divided into three parts. Part 1 introduces descriptive statistics. In this part, a student learns how to download baseball data from a website into a spreadsheet, organize the data into tables, present the data using different types of graphs, and summarize the data using baseball statistics. Part 2 introduces probability. Part 3 is involved with inferential statistics. The student applies confidence intervals and hypothesis testing to baseball research. Three of the research topics include: finding the probability a given player duplicates DiMaggio's 56-game hitting streak, finding what it will take for a current player to hit .400, and finding a method for ranking the top ten hitters of all-time. Sprinkled throughout the course are interesting historical baseball statistics. Examples of actual student presentations will be shown. (Received July 11, 2012)

- 1086-VE-224 **Edward D Smith** (edsmith@pima.edu), 2202 W Anklam Rd, Tucson, AZ 85745, and **Vickey R Smith*** (vrsmith@pima.edu), 2216 W Silverbell Tree Dr, Tucson, AZ 85745. *IBL in redesign for introductory trigonometry classes.* Preliminary report.

This presentation will inform the audience of the ability to create active assignments that allow for student understanding of math concepts. The idea is to bring applications to math and allow for students to gain the knowledge on their own terms. This infusion of inquiry based learning (IBL) is bound with redesign efforts of technology as a replacement. (Received August 07, 2012)

- 1086-VE-232 **David M Glassmeyer** (david.glassmeyer@unco.edu), Campus Box 122, 501 20th Street, Greeley, CO 80639, and **Reshmi Nair*** (reshmi.nair@unco.edu), Campus Box 122, 501 20th Street, Greeley, CO 80634. *Teacher educators' adoption of technology: Longitudinal findings from faculty teaching in a distance mathematics program.* Preliminary report.

The increase in distance-delivered teacher education programs in the United States reflects the need for universities to develop high-quality teachers in an era of strained budgets. Distance-delivered courses allow a wider population of teachers to have access to these programs, offering rural teachers opportunities to engage in courses with minimal travel time and cost; however, research is struggling to keep pace with these advances. What are the best teaching practices in online and hybrid environments, and how can teacher educators, such as mathematicians, be supported in these new environments? This study seeks to describe how teacher educators experienced instructing in a distance-delivered master's program in mathematics. Based on 21 interviews from

eight teacher educators working in a program offering distance-delivered courses for rural teachers, the findings summarize the types of faculty in the program over the last two years based on Rogers' innovation theory. We then offer our recommendations to university personnel and administration for providing support structures to other faculty members who teach using such technologies. (Received September 22, 2012)

1086-VE-292 **Qingxia Li*** (liq@lincolnu.edu), 701 S Providence Road, Apt 1I, Columbia, MO 65203, and **Mara Aruguete** (aruguetem@lincolnu.edu), 701 S Providence Road, Apt 1I, Columbia, MO 65203. *Course Redesign in Elementary Statistics at Lincoln University.*

A large number of African American students in the STEM pipeline at Lincoln University appear to drop out of STEM majors while completing Elementary Statistics and Calculus I. In this talk, several studies will be proposed to examine whether course redesign is effective in increasing knowledge, critical thinking, support systems, and retention of students in Math courses. (Received September 18, 2012)

1086-VE-503 **Timothy A. Redl*** (redlt@uhd.edu), **Rebecca J. Quander** (quanderr@uhd.edu), **Nancy A. Leveille** (leveillen@uhd.edu), **Jacqueline Sack** (sackj@uhd.edu) and **Michael L. Connell** (connellm@uhd.edu). *Recruiting and Preparing Mathematics Majors for Houston-Area Classrooms: The University of Houston-Downtown Noyce Mathematics Teacher Scholarship Program.*

In this session, we will discuss our current NSF Noyce Mathematics Teacher Scholarship program at the University of Houston-Downtown. The purpose of the project is to recruit strong mathematics majors to the field of secondary mathematics education. Recruiting college students to become secondary mathematics teachers has several benefits. Through the scholarship program, we plan to increase the number of high school mathematics teachers with a strong content background, by providing them with a combination of a rigorous mathematics degree program along with specialized courses designed for future high school teachers. We also seek to increase the number of minority and non-traditional students majoring in mathematics and teaching high school mathematics in the Houston area, by offering them scholarships and academic support through the program. Lastly, the program will continue to provide opportunities for UH-Downtown mathematics and education faculty to collaborate and jointly educate future teachers. (Received September 06, 2012)

1086-VE-655 **Becky E Hall*** (hallb@wcsu.edu), 181 White Street, Danbury, CT 06810. *Using a Geometry Common Core State Standard to Teach Function Transformations.*

Students tend to memorize rules for transformations of functions such as "adding a number inside the function moves the graph left". Relying on such rules means students avoid understanding why functions behave as they do. In this talk, the Geometry Common Core State Standard, G-CO 2 will be used to illuminate the behavior of function transformations. (Received September 10, 2012)

1086-VE-668 **Erick Brian Hofacker*** (erick.b.hofacker@uwrf.edu), 214C North Hall, River Falls, WI 54022, **Sherrie Serros** (serrossj@uwec.edu), 502 Hibbard Hall, Eau Claire, WI 54702, and **Kathryn Ernie** (kathryn.t.ernie@uwrf.edu), 206E North Hall, River Falls, WI 54022. *Assessment of Pedagogical Content Knowledge Aligned with Common Core Standards for Pre-Student Teachers.*

During the 2011-2012 school year we collaborated with 16 in-service math teachers from 12 different school districts on a project to assess the pedagogical content knowledge of our pre-student teachers at UW-River Falls and UW-Eau Claire. Each in-service teacher was paired with a pre-student teacher enrolled in our Math Block. Pre-student teachers were assigned a week long unit that they would create, implement, and assess while working with their in-service teacher.

In-service teachers were trained to use a STACK instrument, which was developed as part of a previous project, to evaluate the pre-student teacher when the lessons were taught. The instrument evaluates teaching over three areas: content accuracy, pedagogical content knowledge of teaching and learning, and pedagogical content knowledge of assessment. Pre-student teachers were given a choice of 15 different elements which they wanted to be evaluated on in each of the lessons. Pre and Post conferences were integrated into the process.

At the end of the semester the in-service teachers shared with us their experiences working with the pre-student teachers. Reliability of the STACK instrument was evaluated by the group through watching videos of some of the pre-student lessons. (Received September 10, 2012)

- 1086-VE-669 **Kathryn Ernie*** (kathryn.t.ernie@uwrf.edu), 206E North Hall, River Falls, WI 54022, **Erick Brian Hofacker** (erick.b.hofacker@uwrf.edu), 214C North Hall, River Falls, WI 54022, and **Sherrie Serros** (serrossj@uwec.edu), 502 Hibbard Hall, Eau Claire, WI 54701. *Math Transition into the Common Core Era.*

The Common Core State Standards in Mathematics presents both a theoretical and applied framework to the mathematics students study in K-12. The current plan in the state of Wisconsin is for full implementation and assessment beginning in the 2014-15 school year.

In 2012 we were awarded a multi-year mathematics partnership grant between UW-River Falls, UW-Eau Claire, and the Rice Lake Area School District. Altogether 36 middle school and high school math teachers from multiple districts in Western Wisconsin will participate. The main goal of the project is to better prepare teachers for the areas of mathematics that are addressed in the standards that have not been emphasized in the past.

Our main focus will be on the added emphasis in the standards on modeling, communication, reasoning, and sense making. Each year our cohort group will focus on problems and performance tasks in the conceptual categories of: Algebra, Function, Geometry, Probability & Statistics, and Number & Quantity. Since students will also be assessed over the eight practice standards, the group will also explore questioning techniques and pedagogical techniques that may be used to address these standards. An overview of the structure of the project will be provided. (Received September 10, 2012)

- 1086-VE-726 **Charles Peter Funkhouser*** (cfunkhouser@fullerton.edu), 231 Coursey Lane, Port Ludlow, WA 98365, and **Miles R Pfahl**. *Discovering Universal Connections in Mathematics through Native American Culture.*

This project develops and researches undergraduate mathematics materials based in the culture and mathematics of Native American Peoples for integration into undergraduate courses. Mathematics topics include probability, number theory, transformational geometry, and pre-service elementary and secondary education-related content. These materials—both paper and electronic—are classroom ready, and are developed, piloted and assessed in consultation with Tribes in the the Rocky Mountains, the Plains, the Pacific Northwest, and the Southwest—but are for both Native and non-Native undergraduates. This research is funded by NSF DUE TUES Type 2 award #1122823. (Received September 11, 2012)

- 1086-VE-963 **Brian P. Kelly*** (bkelly@fisher.edu), 118 Beacon St., Boston, MA 02116. *Using Magic Squares To Design Assignments.*

The main idea is to use “partial magic squares” as a means to encourage students to practice fundamental skills. This talk will discuss how to adapt magic squares to address various learning outcomes. Furthermore, the specific learning benefits of these assignments will be highlighted. (Received September 25, 2012)

- 1086-VE-975 **Brian M Loft*** (loft@shsu.edu), Department of Mathematics & Statistics, Sam Houston State University, Huntsville, TX 77341-2206. *Writing and using a set of IBL course notes in differential calculus.* Preliminary report.

Teaching a course using Inquiry- or Discovery-Based Learning (IBL) techniques can be as intimidating as it is rewarding. One of the most important decisions to make when using this method in the classroom is that of choosing the best set of course notes. Of course, one option is to write your own set of notes, making an already intimidating preparation even more daunting. During this talk, we will learn how a set of IBL course notes was written, edited, and used for a differential calculus course, with a thorough discussion of lessons learned. (Received September 17, 2012)

- 1086-VE-994 **Tharanga Mahesh Kumara Wijetunge*** (wijet1tm@cmich.edu), PE 214, Department of Mathematics, Central Michigan University, Mt. Pleasant, MI 48859, and **Dennis St. John**. *The TI-Nspire Navigator CAS system and pre-service teachers: Changing the communication in a mathematics classroom.*

Active participation in classroom activities is one of the key aspects of an effective mathematics classroom environment. It is also vital to have effective mechanisms to identify or rather monitor students’ engagement especially in the presence of technology in a mathematics classroom. The TI-Navigator CAS system allows students to connect their calculators to an instructor-monitored wireless network. The subjects of the current study include pre-service secondary mathematics teachers. This study examines how these students react to this constructive student response system. We are investigating how the different features, for example posing questions and retrieving answers using the system, affect participants’ engagement and learning. Since the subjects are aspiring teachers, we are also investigating how the use of the Navigator system may impact their perspectives on teaching. Finally using the statistical analysis for pre-test/post-test scores of selected

mathematical content, we will see if there are any effects on participants' mathematical achievement as well. By examining students' reactions, perspectives and achievement we hope to gain a better understanding of engagement in a math classroom with an enhanced constructive student response system. (Received September 17, 2012)

1086-VE-1035 **Steven R. Lay*** (slay@leeuniversity.edu). *Preparing Students for Success in Algebra.* Why do so many students struggle with algebra? We believe the primary reason is that they are not thinking correctly about what they are seeing. Most of their errors are usually related to very basic concepts: manipulating signed numbers, fractions, exponents, and canceling. To improve the students' success in algebra, we developed a pre-algebra program to teach them the correct way to think about these basic operations. Our approach involves developing a dynamic model for arithmetic where the emphasis is on an operator changing one number into another number. This presentation will give an overview of the operator approach to pre-algebra and document its successful use with under-prepared college students. (Received September 18, 2012)

1086-VE-1105 **David M Glassmeyer*** (david.glassmeyer@unco.edu), Campus Box 122, 501 20th Street, Greeley, CO 80634, and **Michael C Oehrtman** and **Jodie D Novak.** *Mathematics Teacher Development of Quantitative Reasoning Tasks for Students.* Preliminary report. The Common Core State Standards (CCSS) Initiative (re)defines the types of mathematical knowledge students need to have in K12 education, subsequently changing the expectations for mathematics teachers. Teacher education programs have begun focusing efforts to support teachers in making productive changes to their classrooms that promote student understanding of quantitative reasoning and other standards for mathematical practice given in the CCSS, but little is known about how teachers think about and develop these practices. The authors of this study designed a Model Eliciting Activity (MEA) that was implemented in a master's course for in-service mathematics teachers. Simultaneously documenting and promoting changes in thinking, the MEA asked teachers to construct and revise a quantitative reasoning task intended for their middle and secondary students. Using a models and modeling perspective, the development of the teachers' ways of thinking about quantitative reasoning was analyzed as the teachers revised and implemented the task in their classrooms. This presentation highlights the progression of teachers' thinking about quantitative reasoning as well as the researchers' perspective on what it means for teachers to reason quantitatively. (Received September 22, 2012)

1086-VE-1176 **Margo Alexander*** (malexander@gsu.edu), 30 Pryor Street, Suite 750, Atlanta, GA 30303, and **Iman Chahine.** *Train the Trainer with Technology in Mathematics Education.* This project has initiated a train the trainer with the use of a technology component in the basic mathematics education courses, Foundations, Geometry, Statistics, and Algebraic Concepts. The results will be presented and the future will be discussed.

As part of the plans to improve instruction in mathematics education courses, this project has initiated a train the trainer with the use of a technology component in its basic courses, Foundations, Geometry, Statistics, and Algebraic Concepts. The purpose of this talk is to describe the positive impact of training the instructors has on student outcomes, learning and retention as well as how the use of technology in the classroom has also enhance the teaching and learning of the mathematical concepts. (Received September 19, 2012)

1086-VE-1217 **Jathan W Austin*** (jwaustin@salisbury.edu), Dept. of Mathematics and Computer Science, Salisbury University, 1101 Camden Avenue, Salisbury, MD 21801. *Explorations in Counting and Divisibility: An Example for Undergraduate Mathematics.* Preliminary report.

The presenter will share a mathematical task in which students must count collections of integers with certain divisibility properties. The task is applicable to the teaching of discrete mathematics, elementary number theory, and courses for prospective high school teachers. (Received September 20, 2012)

1086-VE-1494 **Suzanne Mitchell*** (suzmitch@comcast.net), 6 Foxwood Cove, Jacksonville, AR 72076. *Mathematics Leadership Requires Growth and Responsibility.*

Members of the mathematics education community have a responsibility to help one another build personal and professional leadership capacity. This presentation will offer concrete ways to help mathematics teachers and leaders build their knowledge, performance, and influence using resources and connections to the Common Core State Standards in Mathematics. In particular, the PRIME Leadership Framework: Principles and Indicators for Mathematics Education Leaders, will be highlighted to show the three stages of mathematics leadership: 1) Leadership of Self- know and model; 2) Leadership of Others - collaborate and implement; and 3) Leadership in the Extended Community - advocate and systematize. To support the stages of leadership, action indicators of

leadership revolve around equity, teaching and learning, curriculum, and assessment and these will be discussed in light of developing success for every student, teacher, and leader. (Received September 22, 2012)

- 1086-VE-1529 **Manyiu Tse*** (mtse@molloy.edu), 107 East Maujer Street, Valley Stream, NY 11580. *A Pilot Study on the Impact of Incorporating Problems with Incorrect Solutions into Exams on Students' Understanding of Mathematical Concepts.*

Students often learn mathematics through examples that have been worked out, and are then tested with similar questions. However, correct solutions written by students are not always indicative of their understanding of the mathematical processes behind the problems. This can be shown by revising a studied example that is outside of a student's thinking box. One way to enhance the students' reasoning and math communication is to look at problems with erroneous solutions. To facilitate this study, five questions with incorrect solutions were embedded in an exam, and the students were asked to identify and explain each error. What follows is both a qualitative and quantitative analysis of the study. (Received September 23, 2012)

- 1086-VE-1560 **C. Adam Feldhaus*** (cafeldhaus@gmail.com), 1072 Weybridge Rd., Apt. D, Columbus, OH 43220. *Online Mathematics Tutoring at a Community College.* Preliminary report.

In 2009, Columbus State Community College (CSCC) received a Title III Grant in part to improve the tutoring infrastructure at the college. One of several initiatives created with help from this grant was creating an online tutoring service for lower-level mathematics courses. This talk will discuss some of the reasons the college chose to implement online tutoring, how the college presently uses online mathematics tutoring, how successful online tutoring is when compared to traditional mathematics tutoring at the college, and how CSCC plans to expand online mathematics tutoring in the future. (Received September 23, 2012)

- 1086-VE-1640 **Suzanne I Doree*** (doree@augsborg.edu). *Just enough algebra – a new approach to preparing college students.*

In 1994, my colleagues at Augsburg College and I had a vision for a new course to replace our intermediate algebra course. We wanted a college level course that would serve primarily as preparation for quantitative courses across the curriculum. The framing question that led to our curricular adventure of the past nearly two decades was: What algebra do college students need to know, and how can we make it relevant to their future studies, their lives as citizens, and their everyday life? From these questions *Just Enough Algebra* was born.

Everything we do in the course is set in some applied context. Our choice to focus primarily on linear and exponential models; to emphasize verbal, numerical, and graphical interpretation of functions; and to include only the most essential symbolic techniques align well with curricular guides from the MAA and AMATYC. More importantly, it works. Student learn a lot in this course. They are ready for what comes next. And, they enjoy it.

In this talk I will outline the process used for constructing the course; describe the course curriculum, pedagogy, and supporting instructional materials; and show a couple of examples to illustrate the approach. (Received September 25, 2012)

- 1086-VE-1660 **Paul C Fonstad*** (pfonstad@franklincollege.edu), 101 Branigin Blvd., Franklin, IN 46131. *The Passport Project for an Interactive Classroom.*

One of the keys in helping students who normally struggle in a math class succeed is encouraging them to work with their peers to overcome math challenges. Originally developed as an activity for reinforcing the processes for solving systems of linear equations, the passport project is an excellent tool for encouraging full classroom participation, peer tutoring, and teaching a wide variety of math concepts to a developmental class. (Received September 23, 2012)

- 1086-VE-1662 **Osama Taani*** (otaani@plymouth.edu), Plymouth State University, Mathematics Department, 17 High Street, MSC 29, Plymouth, NH 03264. *Using Original Historical Sources in Teaching Mathematics for Preservice Elementary and Middle School Teachers.*

120 pre-service teachers participated in an experiment about using original sources in teaching mathematics for preservice elementary and middle school students. Several excerpts from Al-Kashi's 1427 Key to Arithmetic have been translated from Arabic and used in this study. These excerpts present multiple algorithms for multiplication, multiple mensuration formulas, and multiple problem solving methods. Several important findings will be discussed such as creating networks of ideas, providing flexibility of thinking, providing opportunities for comparison, and improving creativity. (Received September 23, 2012)

- 1086-VE-1745 **Andrew Bucki** (ajbucki@langston.edu) and **Abebaw Tadesse*** (atadesse@langston.edu). *New Educational Program in Mathematics for STEM Majors, Part II*. Preliminary report.

This presentation is a continuation of the first part of "New Educational Program in Mathematics for STEM Majors". In this part we illustrate the ideas of the program with concrete examples. (Received September 24, 2012)

- 1086-VE-2012 **Homer W. Austin*** (hwaustin@salisbury.edu), 1101 Camden Avenue, Salisbury, MD 21801. *Logical Inference vis-a-vis Information Processing/linguistics*. Preliminary report.

Logical inference is crucial for valid mathematical arguments; however, many college/university students will state that they are not good with this aspect of mathematical inquiry. Some preliminary findings from a small pilot study will be shared and some possible linguistic connections will be explored against a theoretical background (framework) from cognitive psychology. (Received September 24, 2012)

- 1086-VE-2218 **Dickson S. Ondiek Owiti*** (owitidick@yahoo.com), Dr. Dickson S.O Owiti, Kisii University College, Box 408-40200, Kisii, 40200, Kenya. *The State of Mathematics Education in Africa: Building a strong foundation for global competitiveness*.

Mathematics plays an important role in scientific advancement and technological development of any nation. Performance in the subject worldwide has not been impressive. International comparative studies on students' attitude, engagement and performance in science and mathematics (PISA & TIMSS) have singled out teachers' teaching practices as wanting. Too often mathematics is taught by teachers describing how to solve a type of maths problem, doing few examples on the board and then setting an exercise for students. Therefore, Mathematics Education curriculum teachers of mathematics go through at the universities and other colleges need constant revision, changes and innovations based on experience and research if effective teachers of 21st century are to be produced. This paper attempts to review and present research findings on the state of mathematics education in Kenya and makes comparison with success cases of Japan, China, Singapore, Hong Kong, Korea and Germany. It then attempts to discuss some of the required reforms and innovations needed to reposition teaching and learning of mathematics in Kenya for effective global competitiveness.

Keywords: Mathematics Education, Teacher education, Teaching practice, Global competitiveness (Received September 25, 2012)

- 1086-VE-2242 **Christopher C. Leary*** (leary@geneseo.edu). *Elementary mathematics education: What has been, what is, and what might be normal*.

An examination of a slice of the history of the training in mathematics that we provide to students who are entering elementary education. How has what we have taught preservice teachers changed over time, and how might it change in response to the Common Core? How has the Common Core addressed or not addressed the challenges faced by our future teachers, their students, and the mathematics community? Like this abstract, we have more questions than answers. (Received September 25, 2012)

- 1086-VE-2267 **Darlene M Olsen*** (dolsen1@norwich.edu), 158 Harmon Drive, Northfield, VT 05663. *Engaging Undergraduate Nursing and Health Science Students in Advanced Statistics*.

Increasing expectations in the Bachelor of Science in Nursing curriculum has landed the sophomore Nursing majors at the university in a second semester statistics course. This course covers topics such as statistical measures of screening tests, odds ratio and relative risk, ANOVA, non-parametric tests, and multiple regression. This presentation will share strategies and examples used to increase nursing students' interest in statistics. (Received September 25, 2012)

- 1086-VE-2322 **Soofia Malik*** (soofia.malik@unco.edu), 501 20th street campus box 122, Greeley, CO 80631, and **Karen Traxler** (karen.traxler@unco.edu), 501 20th street campus box 122, Greeley, CO 80631. *Investigating Undergraduate Students' Attitudes and Achievements through Writing in Blackboard Discussion Board in College Algebra Course*. Preliminary report.

The present study is a pilot study conducted to analyze the effects of writing in Blackboard's Discussion Board on students' mathematics attitudes and achievements over two sections of a College Algebra course in a university in the US. 70 students with little or no background in mathematics participated in this study (M=41, F=29). The study was conducted in two phases. During Phase I, one class was designated as the treatment group (N=36) and the other as the control group (N=34). The first half of the course covered identical material and during the latter half, students in the treatment group were required to reflect by writing on Blackboard's Discussion Board about the course content. To analyze the achievements data, a MANOVA and an independent samples t-test

were conducted. During Phase II, the treatment group completed a modified version of the Mathematics Attitudes Scale. The modified instrument's reliability was examined using Cronbach's alpha and split-half reliability coefficients. The responses on the attitude survey showed high attitudes toward mathematics. Results suggest that while gender did not make a difference in attitude scores, class rank did. This presentation will expand upon the results and future directions for this study. (Received September 25, 2012)

1086-VE-2365 **Janet Nichols*** (janet.nichols@colostate-pueblo.edu). *Happiness is receiving a Noyce Grant - but who knew it would be this hard to award scholarships?* Preliminary report.

A Robert Noyce Teacher Scholarship Grant was awarded to Colorado State University – Pueblo in August, 2011. After a year and a half of Noyce support (NSF Grant Number DUE 1136426), questions about what we've accomplished and what is yet to be done will be addressed. Items to be discussed will include the development of the application form, the interview questions, and the promissory note; the creation of a website and brochure; and ways in which we publicized scholarship opportunities. Issues that arose related to the amount a recipient could receive with respect to cost of attendance, other federal scholarships and loans, and unmet needs will also be discussed. An overview of our scholarship and professional stipend recipients will be given including how this program has affected their lives and our hopes for how it will affect mathematics education in our local school districts. (Received September 25, 2012)

1086-VE-2414 **Benjamin Atchison*** (batchison@framingham.edu). *Adapt or Die: A 1.5 Year Quest for an Engaging Course in College Algebra.*

At Framingham State University, a 4-year public college, the teaching responsibility for each mathematics department faculty member typically includes two sections of a terminal general education course (most often College Algebra or Introductory Statistics). This talk centers on the continual struggles of one junior faculty member in having to teach six sections of College Algebra, to an average class size of thirty students and over a period of three semesters. In particular, we will discuss: (1) the philosophy of how to approach such a course, (2) those innovations that were made to the course requirements, support services, and preparation/presentation, (3) what worked and what did not, and (4) developing strategies for future semesters. (Received September 25, 2012)

1086-VE-2429 **Suriza Van der Sandt***, The College of New Jersey, 2000 Pennington Road, Department of Mathematics and Statistics, Ewing, NJ 08628, and **Cathy Liebars** and **Shilpa Nandwani**. *Math Education of Deaf and Hard-of-Hearing Students - A Silent Crisis?* Preliminary report.

Hine (1970) reports that 10-year old Deaf and Hard-of-Hearing (DHH) students had an arithmetic age of 8, and 15-year-olds an arithmetic age of 10 years. We propose to present evidence that there still is a significant deficiency in the quality of math education in DHH high schools despite mandatory requirements to meet the Individuals With Disabilities Education Improvement Act of 2004 and No Child Left Behind Act of 2001. Evidence would include data from scholarly publications and national and state data, e.g. Anita et al. (2009) found that by high school about 50% of their national sample of DHH students was performing below basic proficiency in math. In California, 62% of the Grade 10 DHH students failed the California High School Exit Exam. As mathematicians and educators such results from across the country should be very disappointing and troublesome as poor math skills limit opportunities for DHH students to follow a career path in which math or science plays a major part. (Received September 25, 2012)

1086-VE-2436 **Jacob Sloujitel*** (jsloujit@globe.edu), 500 7th Avenue, New York, NY 10018. *Students' difficulties for studying undergraduate mathematics.* Preliminary report.

This presentation describes the results of research on the learning difficulties in statistics, discrete mathematics, pre-calculus, and calculus. Statistical analysis of student scores in the pre/post tests shows significant improvement for solving equations, constructing frequency distributions, calculating measures of central tendency, finding derivatives, evaluating integrals. Students have difficulties for understanding the graph theory, decision making process, hypothesis testing, optimization procedure. The methods for overcoming these problems are proposed in the presentation. (Received September 25, 2012)

1086-VE-2520 **Andrew J Cousino*** (acousino@ksu.edu), 11506 W. 143rd Terrace, Olathe, KS 66062. *Data-mining to track student attitudes.*

Previous research has shown that student attitudes are very important in student success (or lack of success) in college algebra. Using data-mining techniques we have developed Bayesian and hidden Markov Models of how student attitudes evolve during a college algebra course. The ultimate goal is to improve retention by

delivering appropriate support to the right students at the right times. This approach should extend to other introductory/developmental courses. (Received September 25, 2012)

1086-VE-2531 **Fabiana Cardetti, Gabriel Feinberg*** (gabriel.feinberg@gmail.com) and **Catherine Matta**. *A New REU Program in Mathematics Education Research.*

As part of the 2012 summer REU program, the University of Connecticut Mathematics Department introduced mathematics education as one of the research topics. Before the summer, we worked to determine the focus of the project, set summer-long goals, and outline the project activities. One of the highlights of the summer work was a mock educational study we conducted to explore the perceived learning difficulties in multivariable calculus classes.

In this session, we'll share some of the challenges we faced in developing a new REU program, and how our plans evolved over the summer. We'll also showcase the materials we created for our study and the results we collected. (Received September 25, 2012)

1086-VE-2540 **Kevin J. Haertzen*** (haertzek@uwplatt.edu), 1 University Plaza, Department of Mathematics, 458 Gardner Hall, Platteville, WI 53818. *Survey on College Students Experience in their first College Mathematics Course.*

A team of University of Wisconsin-Platteville math faculty initiated a two-year state-funded project with college students and area high school teachers to improve students' transition from high school to college math. The goal was to increase student success in their first college math class. To better understand our students, we surveyed students in selected lower level mathematics courses. Student participation was voluntary, and all data collected was self reported by the students. We wish to share the results of our surveys. (Received September 25, 2012)

1086-VE-2655 **Jale F. Akyurtlu*** (jale.akyurtlu@hamptonu.edu), 168 Marshall Avenue, OLIN Engineering Building, Hampton, VA 23668, **Otsebele Nare** (otsebele.nare@hamptonu.edu), 168 Marshall Avenue, OLIN Engineering Building, Hampton, VA 23668, and **Shari Wiley** (shari.wiley@hamptonu.edu), **Anne Pierce** (anne.pierce@hamptonu.edu) and **Gertrude Henry** (gertrude.henry@hamptonu.edu). *HR-PAL: A partnership to enhance Algebra performance.*

The goal of the HR-PAL partnership funded through the NSF MSP-Start program is to engage both higher education and K-12 faculty in building an effective partnership to enhance problem-solving skills in algebra. This initiative includes Hampton University faculty from engineering, mathematics, education, and art departments working with K-12 mathematics, technology and art teachers from the Hampton Roads area schools to develop a "system analysis" approach to teaching. In this talk, we will address the successes of our program with training teachers to embrace the system analysis and design approach to teaching algebra, and how art, and technology projects can be successfully implemented into mathematics discussions. In particular, we will discuss design projects, which utilize algebra and technology, that were successfully completed by secondary school teachers at a summer teachers institute held at Hampton University, and are in the beginning stages of being implemented into select school systems in the area. We will, also, discuss how art classes will be used to reiterate the knowledge acquired in the algebra courses. (Received September 25, 2012)

1086-VE-2771 **Alexander G. Atwood*** (atwooda@sunysuffolk.edu), 533 College Road, Selden, NY 11784. *How Can Cardiovascular Exercise Change the Brain and Improve the Learning of Mathematics?* Preliminary report.

Recent research at the University of Illinois at Urbana-Champaign by A.F. Kramer and collaborators shows that cardiovascular exercise significantly increases the volume of a key region of the human brain involved in learning, the hippocampus, and improves cognition related to long term memory encoding, storage and retrieval in children. What are the possible biochemical and physiological mechanisms of this change in brain structure and in cognition, and how can cardiovascular exercise improve the way in which students learn mathematics? (Received September 25, 2012)

1086-VE-2800 **Kirsty Eisenhart*** (kirsty.eisenhart@wmich.edu), 3326 Everett Tower, Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008-5248. *Relearning algebra: Transitioning to learning mathematics with meaning.* Preliminary report.

The data discussed is part of a larger study undertaken to determine the degree to which course assessments in newly revised developmental mathematics courses reflected the overall goals of the courses, and the degree to which students were making the transition to thinking about mathematics in a meaningful way. The items that serve as the focus of this talk require students to use a given context to explain the practical meanings

of a function at a particular point and the slope of a function. Despite the overall course emphasis on using real-world situations as a tool to understanding mathematics, a large portion of Algebra I students essentially ignored the given contexts. The analysis suggests that the specific context used in the task makes a difference, and perhaps students are more likely to abandon contexts with which they have less familiarity. Another issue not directly dealt with in this study is the differences in the ways real world contexts were utilized by different course instructors during class. Although all instructors were using the same text, and met weekly with the director to discuss the lesson goals, their implementation of the curriculum varied greatly. (Received September 25, 2012)

1086-VE-2920 **Lipika Deka*** (ldeka@csusb.edu), 100 Campus Center, Seaside, CA 93955. *Fostering habits of mind for students in developmental mathematics courses through Early Alert System*. Preliminary report.

This talk will discuss how at California State University-Monterey Bay (CSUMB) a system called Early Alert System is used to improve the student success for the developmental mathematics courses. For last five years CSUMB has been running a very successful developmental mathematics program. One of the core factors of the success of this program is an Early Alert System that is used to alert the students several times during the semester to keep them on track if they are struggling. The early alerts are sent in a very friendly way to encourage the students to stay focus. An alert is an encouraging constructive feedback that is sent either by email or in person or in class to each individual student who needs extra support. The system was first started to improve retention of students in this courses since this was the main reason for failure in developmental courses. But, the system ended up doing way more than what was expected. It helped student to form habits of mind, taught them to be more engage in class, to be persistent and to be responsible for their own learning. The talk will discuss how the system work and how fostering the habits of mind helped students to be successful in the developmental mathematics courses. (Received September 26, 2012)

1086-VE-2964 **Ping Wang*** (pxw10@psu.edu), 200 University Dr., Schuylkill Haven, PA 17901, and **Mike Gallis**, 200 University Drive, Schuylkill Haven, 17972. *Technology in Math Classes*.

Graphics and interactive computer programs can be very useful in introducing mathematical concepts and procedures visually when they are discussed in class, enabling students to have the relevant pictures and processes in mind. Classroom learning activities can be greatly enhanced by such use of such technology. (Received September 26, 2012)

General Session on Mathematics and Technology

1086-VF-277 **Jack Y Narayan***, Mathematics Department, SUNY Oswego, Oswego, NY 13126. *Classroom practices which integrate a variety of technological and communication tools to improve student learning in a Finite Mathematics and Applied Calculus*.

We engage students, many of whom are underprepared in college algebra, in a large class with a variety of tools including Microsoft Excel, graphing calculators, tablets, smart phones, instructor created videos, and the WebAssign homework management system in order to enhance student learning. Students are required to bring their laptops and mobile devices for solving problems and taking notes in class. WebAssign extends the learning outside of the classroom. It provides students with e-book access and feedback on assignments. In a one-semester required course, we emphasize spreadsheet algebra to explain the difference quotient, inverse functions, piecewise defined functions and properties of logarithmic and exponential functions. Numerical derivatives are used to motivate the concept of limits as part of the understanding of the definition of the derivative. We create videos with tablets and laptops to reinforce concepts and provide feedback on homework problems. Students also create videos. These videos are on the WebAssign server as resources for students to access on their computers or mobile devices. We find that our strategies, which integrate technology in this manner, are effective with this audience and improve students' chances of success in subsequent classes. (Received August 15, 2012)

1086-VF-354 **Neil Sigmon*** (npsigmon@radford.edu), Department of Mathematics and Statistics, P.O. Box 6942, Radford, VA 24142, and **Rick Klima** (klimare@appstate.edu), Department of Mathematical Sciences, Boone, NC 28608. *Using Graphs to Break Ciphers in Cryptography Using Maplets*.

In cryptography, monalphabetic ciphers, which rely on a single ciphertext alphabet to encrypt a plaintext message, have for many years been known to be insecure since frequency analysis can be used to discover the key by using the most likely plaintext/ciphertext character pairs. Polyalphabetic ciphers, when first used, represented a major upgrade over monoalphabetic ciphers since individual plaintext letters were encrypted using

multiple cipher alphabets. However, if the number of cipher alphabets used can be discovered, polyalphabetic ciphers are themselves vulnerable through using frequency analysis on the individual cipher alphabets. This talk discusses how polyalphabetic ciphers, in particular, the well-known polyalphabetic Vigenere keyword cipher, can be broken using graph comparisons involving the frequency distributions of certain ciphertext letters. In order to generate the graphs and perform the comparisons, a Maplet will be used. (Received September 19, 2012)

1086-VF-355 **Wei Wei*** (wei.wei@metrostate.edu), Department of Mathematics, Metropolitan State University, 700 East 7th Street, Saint Paul, MN 55106, and **Zhi Qiao** (geozhi@gmail.com), Minneapolis, MN. *Effects of using tablets in lectures on student learning outcomes in mathematics courses.*

Studies have shown that the use of tablets facilitates learner-centered education in mathematics, statistics and engineering. However, there is no research comparing student learning outcomes from the lectures using a tablet to those using whiteboard or PowerPoint slides. In this study, we investigated whether students are in favor of lectures using tablets and whether using a tablet to teach leads to better learning outcomes compared to lectures using white board or PowerPoint slides. Data were collected from quiz grades and attitude surveys at the end of each chapter from an undergraduate Statistics and Discrete Mathematics course. Each chapter was taught with one of the three methods: tablets, PowerPoint slides and white board. Our results are: student quiz grades were significantly higher when using tablets or PowerPoint slides in lectures than using white board; the use of tablets and PowerPoint slides were significantly favored over white board; and student quiz grades and attitudes toward lectures with PowerPoint slides are not significantly different to those using tablets. (Received August 24, 2012)

1086-VF-425 **Daniel J Heath*** (heathdj@plu.edu), Morken Center 258, Pacific Lutheran University, Tacoma, WA 98447. *Geometry Playground v. 1.4.*

We introduce *Geometry Playground v. 1.4* (GP), free dynamic geometry software for multiple geometries. Notably, GP allows straightedge and compass constructions in Euclidean, Manhattan, spherical, projective, and hyperbolic geometries, as well as limited constructions in toroidal and conical geometries. This allows GP to be used for discovery activities in classes ranging from Euclidean and non-Euclidean geometry to trigonometry and topology. (Received August 31, 2012)

1086-VF-513 **Hossein Behforoos***, Utica College, Mathematics Department, Utica, NY 13502. *Some Notes on the Calculation of the Continued Exponents.* Preliminary report.

Continued Radicals and Continued Fractions are very popular and interesting subjects to study. In this talk we will present one or two continued exponents problems. Also, I will mention a bad news about how most of our graphing calculators, math software and many new born electronic devices are not well-programmed to follow the well-known and well-defined mathematical conventional rules in calculating double or higher order of exponents. (Received September 05, 2012)

1086-VF-717 **Petre Ion Ghenciu***, ghenciu@uwstout.edu. *Teaching online mathematics courses with an accent.* Preliminary report.

Teaching online courses, if not done properly, can be challenging for the instructor as well as the student. Add to the mixture online mathematics and statistics courses and you get everybody's attention... How about mathematics and statistics graduate courses? This presentation will provide a summary of the use of Blackboard Collaborate in my classes to enhance interaction. Some activities and findings about this subject will be presented(with an accent, of course...). (Received September 11, 2012)

1086-VF-758 **Daniel Lee McGee**, PO Box 5000, Mayaguez, PR 00682, **Pedro Vazquez-Urbano*** (pedro.vasquez@upr.edu), PO Box 5000, Mayaguez, PR 00682, and **Jesus Cajigas**. *Online Remedial Mathematics to Enter Precalculus: An analysis of the relative value of a traditional classroom courses vs an online course.* Preliminary report.

To assure that students in STEM fields entering Precalculus have the appropriate prerequisites, the University of Puerto Rico administers a math diagnostic exam to "at risk" entering freshmen where "at risk" is a score below 650 on the mathematics college entrance exam for Puerto Rico. The diagnostic exam focusses on elementary and middle school mathematics and students need to receive 50% or better in order to pass this exam. Currently, 58% of entering freshmen at the UPR cannot pass this exam. From 2008-2010, "at risk" students that failed the diagnostic exam were required to register for a semester long traditional classroom course. In an effort to see if results could be improved, starting in the fall semester of 2011, this traditional remedial course was discontinued and replaced with a three week all day, primarily online, remedial course that was normally taken the summer before entering the UPRM. Comparing the two approaches, we found that the online course allowed over 60%

more students with math deficiencies to pass precalculus their first semester. This presentation will present these two courses along with an overview of performance both in the remedial course and in the subsequent precalculus course. (Received September 12, 2012)

1086-VF-812 **Barbara Margolius*** (b.margolius@csuohio.edu), Cleveland State University, Mathematics, 2121 Euclid Ave, Cleveland, OH 44115. *Series Tic-Tac-Toe.*

Proving the convergence or divergence of infinite series is one of the more difficult topics typically covered in a second semester calculus course. In this talk I demonstrate an HTML5 applet that takes a game-like approach to learning about series. The applet will be embedded in a WeBWorK homework problem but also may be used independently. This work is supported in part by NSF-DUE-0941388. (Received September 25, 2012)

1086-VF-967 **Alexander Y Vaninsky*** (avaninsky@hostos.cuny.edu), 450 Grand Concourse, Room B409, Bronx, NY 10451. *A Mathematician's View of Educational Neuroscience: A Hunt for a Mathematical Genius.*

In recent years non-invasive methods of neuroscience research on learning mathematics were developed: functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and near infrared spectroscopy (NIRS). They paved the way to the determination of the brain domains responsible for the acquisition and storage of mathematical knowledge, with the parietal cortex playing the most important role. Neuroscience allows for the estimation of the latent ability of an individual to solve difficult mathematical problems. Recent studies were limited to either very simple arithmetic calculations or to the multiple choice problems. With the increase in the knowledge of brain activity and the improvements of the neuroscience investigation it becomes possible to develop more elaborated methods of early recognition of the extraordinary mathematical abilities and find individuals with genetically rich mathematics - related zones of their brains. This approach, as opposed to tests, is indifferent to race or socioeconomic status. Systematic selection of potentially talented youngsters will allow for the increase in the probability of finding a mathematical genius. We discuss different neuroscience techniques together with the methodology and possible ways of selection. (Received September 25, 2012)

1086-VF-1023 **Daniel Gries*** (djg@dagries.com), 255 W Elm St, Second Floor, New Haven, CT 06515. *Customizable graphical user interface applets integrated with WeBWorK calculus problems.*

We will present a collection of applets created in Adobe Flash which are made to be embedded in WeBWorK problems. The applets allow calculus concepts to be communicated graphically between instructor and student, by allowing function graphs to be shaded, labeled, and investigated by the student according to criteria set by the problem author. Customization is possible within the PG code defining the WeBWorK problems, without the need to alter the Flash applets in any way. We will present several examples of applet enhanced WeBWorK problems, and discuss some of the pedagogical approaches and challenges associated with this type of user interface. This work is supported by NSF-DUE-0941388. (Received September 23, 2012)

1086-VF-1369 **Matthew Leingang*** (leingang@nyu.edu), 251 Mercer St, New York, NY 10012. *Electronic grading of paper assessments.* Preliminary report.

How can we grade quizzes and tests given on paper in a paperless way? Armed with a scanner, some software, and a few scripts, the author has developed a document workflow aimed towards this goal. In addition to freeing the office from clutter, we gain the added capabilities of mobile grading via tablet devices, finer recording of response data, additional security, and digital archiving with rich metadata. (Received September 21, 2012)

1086-VF-1382 **Samuel Charles Herwood*** (sherwood@adelphi.edu), Adelphi University, Dept. of Math and CS, 1 South Avenue, Garden City, NY 11530. *Resurrecting Hinton's Tesseract: Using 3D Graphics to Emulate the Four-Dimensional Models of Charles Howard Hinton.*

Through a large body of work, the mathematician Charles Howard Hinton (1853-1907) believed he had come up with an intuitive thought process for anyone to understand and visualize four spatial dimensions. In the century since Hinton's death, his work has waned in prominence and almost none of his writings are available in their original form. His system for visualizing the fourth spatial dimension was based on a set of colored wooden cubes presented in succession. We will use 3D computer graphics to gain insight into this system of cubes, as well shed some light on the nature of the fourth spatial dimension in general. (Received September 21, 2012)

- 1086-VF-2075 **Troy A. Bupp*** (troy.bupp@usma.edu), United States Military Academy, Department of Mathematical Sciences, Building 601 (Thayer Hall, Office TH233), West Point, NY 10996. *The Benefits of Using Email to Maintain Instructor Accessibility in Assisting Student-Driven Learning of Mathematics.* Preliminary report.

The U.S. Military Academy requires that students arrive to math class having already read their assigned textbook reading and worked through related homework problems prior to that day's classroom instruction. Once in the classroom, instructors often begin class by answering students' well-formed questions or by calling upon them to demonstrate their proficiency in the new material. To reduce potential obstacles to student-driven math learning prior to the classroom, my approach is to maintain availability and responsiveness through email during a structured time period when student preparation is likely to occur. Analysis of student emails during a one-year pilot study of this structured instructor availability reveals a number of qualitative and quantitative outcomes indicating the benefits of this approach. The qualitative outcomes apply both to assist the student in learning math and to assist the instructor with improving lesson preparation. Instructors contemplating to implement a similar email opportunity for their students can leverage the quantitative outcomes provided to shape their own desired results for their class instruction. The presentation will finish with a general discussion about the importance of maintaining accessibility beyond the normal academic day. (Received September 24, 2012)

- 1086-VF-2336 **Reza O Abbasian*** (rabbasian@tlu.edu), 1000 W. Court St., Dept. of Math & Computer Science, Texas Lutheran University, Seguin, TX 78155, and **John T Sieben** (jsieben@tlu.edu), 1000 W. Court St., Dept. of Math&Computer Science, Texas Lutheran University, Seguin, TX 78155. *A Brief Tutorial on Building a "Flipped" Classroom.*

The authors will outline the steps to design a "flipped" classroom which is an inverted version of the traditional lecture-based instruction. Students watch lectures outside the classroom at their own pace and spend their class time in group activities and working problems with their instructor. The Khan Academy's web site contains more than 3000 mini-lectures and tutorials which can be viewed on YouTube or directly from the Academy website. These videos contain most of the topics in undergraduate mathematics ranging from College Algebra to Multivariable Calculus. For those topics where the online resources are not available or do not fit your course, we will describe the details of creating your own mini-lectures. We will demonstrate the steps leading to the production of a sample 10-minute lecture using a pen-tablet with a brief discussion of the technical complexities and the choice of software and hardware. Our presentation is intended for mathematics and/or statistics educators with interest in using technology in their classroom teaching. (Received September 25, 2012)

- 1086-VF-2456 **Nathan C Carter*** (ncarter@bentley.edu), Bentley University, 175 Forest St., Morison 317, Waltham, MA 02452, and **Kenneth G Monks.** *Lurch: a word processor that checks students' mathematical reasoning.*

Lurch is a free math word processor for Windows, Mac, and Linux systems. The user can designate expressions and phrases in their document as having mathematical meaning, and Lurch will check the reasoning and structure in their work, giving detailed feedback about everything from syntax to proof structure. Instructors can teach Lurch the rules they permit in their courses, and Lurch will respect those rules when checking their students' work. This talk will demonstrate the software, cover practical ways it can be used in a course, overview the theoretical framework on which it's built, and mention future development efforts. (Received September 25, 2012)

- 1086-VF-2548 **Mark C Ginn*** (ginnmc@appstate.edu), Dept of Mathematical Sciences, Walker Hall, Appalachian State University, Boone, NC 28608. *Teaching hybrid online classes to secondary school teachers.*

We will discuss our experiences taking our MA program in Secondary Education to a hybrid online format. This will involve a discussion of student reactions, instructor adaptations, and the general impressions from those involved. (Received September 25, 2012)

- 1086-VF-2563 **Jonathan D Dunbar*** (jdunbar@shc.edu), Spring Hill College, 4000 Dauphin St., Mobile, AL 36608. *Lore.com: Experiences Using This Free Online Course Management System in a Liberal Arts Math Class.* Preliminary report.

There are a number of web-based course management systems. Many of these have begun charging individuals, departments or institutions for their use. Lore is one system which has not, and claims that it never will. Originally CourseKit, Lore is a new take on course management systems which also has the goal of being an apparatus for social networking. Because Lore is styled as a social network, and not a spreadsheet, the online

appearance of a course employing Lore is already familiar to the students. In addition, its style encourages students to collaborate, comment, and correct each other's work. This talk will cover the Lore-based experiences had by two sections of a mathematics for Liberal Arts course and their professor over the course of one semester, including its benefits, as well as its current limitations. (Received September 25, 2012)

1086-VF-2683 **Michael D Hvidsten*** (hvidsten@gac.edu), 800 West College Avenue, Saint Peter, MN 55108. *Interactive Math Texts on the Web using MathJax, JSXGraph, and HTML5.*

There has been a convergence of three different technologies that now provide a simple, yet powerful, platform for the development of interactive math texts on the web. These freely available technologies include MathJax – an open source JavaScript display engine for mathematics, JSXGraph – an open source JavaScript library for interactive geometry, function plotting, charting, and data visualization in web browsers and other devices such as the Ipad and Android tablets, and the new HTML5 format which includes a rich set of video, audio, and drawing canvas elements, along with native support for MathML.

In this talk, the presenter will discuss his experience in translating several chapters of a traditional geometry textbook into an on-line interactive text using these three technologies. (Received September 25, 2012)

1086-VF-2761 **L. Felipe Martins***, Cleveland State University, Department of Mathematics, 2121 Euclid Ave., Cleveland, OH 44115, and **Barbara Margolius** and **Dan Gries**. *Flash-enhanced WeBWorK problems in Differential Equations.* Preliminary report.

We present a series of problems in differential equations for the WeBWorK on-line homework system. The problems are enhanced by the use of Flash applets, allowing a higher level of student interactivity. (Received September 25, 2012)

General Session on Modeling and Applications of Mathematics

1086-VG-59 **Edward F Aboufadel*** (aboufadel@gvsu.edu), Dept. of Mathematics, A-2-178 MAK, Grand Valley State University, Allendale, MI 49401. *Analysis of Diabetes Data Using Wavelet Scalograms.*

Type-1 diabetes is an autoimmune disease that requires constant attention in order to keep a patient's blood glucose in an acceptable range. In recent years, type-1 diabetic patients have begun to use continuous glucose monitors (CGMs) to monitor their blood glucose. In this paper, we describe mathematical methods to create reports based on streams of CGM data, so that blood glucose management can be improved. The mathematical tools used to create the reports includes wavelets scalograms and multidimensional scaling. (Received June 25, 2012)

1086-VG-114 **Shiv Raj Singh*** (shivrajpundir@gmail.com), Department of Mathematics, D.N. College, Railway Road, Meerut, UP, India. *An Integrated Fuzzy Production Model with shortages Under Two Warehouses.*

In this paper, we develop a two warehouse production model with imperfect items. Production rate is taken as the linear combination of on-hand inventory and demand, while demand rate is taken as function of time. Most of the researchers consider that the production rate is independent from the demand rate. In this paper we assume production rate as dependent on the demand rate and this assumption is more realistic. Shortages are allowed and partially backlogged with time dependent backlogging rate. Due to different preservation facilities we consider the deterioration rate is time dependent in own warehouse (OW) and Weibull distribution deterioration in rented warehouse (RW). Holding cost in RW is greater than in OW. We developed a fuzzy model with fuzzifying the carrying cost of OW and RW as triangular fuzzy numbers. The present model is developed in both crisp and fuzzy sense. Finally, numerical example is shown and sensitivity is also illustrated. (Received July 23, 2012)

1086-VG-230 **Adam F Childers*** (childers@roanoke.edu), MSCP Department, 221 College Lane, Salem, VA 24153. *V-Optimal Experiment Designs for Non-Linear Models.* Preliminary report.

In this presentation we will investigate techniques for finding V-optimal or near V-optimal experiment designs for non-linear models with bounded errors. Using an inverse method to find the membership set, we will discuss the relationship between V-optimal designs and optimal designs associated with models with normally distributed errors. Further, we will use the sensitivity of the membership set with respect to the parameter of interest and

the magnitude of the bounded error to understand how to find designs that are both V-optimal and robust. (Received August 09, 2012)

1086-VG-269 **Andrew G. Borden*** (bordon1@att.net), 680 E. Basse Rd., #226, San Antonio, TX 78209. *The Influence of Evolutionary Psychology on Natural Selection*. Preliminary report.

It is counter-intuitive that natural selection would favor personality traits related to altruism and other forms of cooperation in society. However, when human beings formed permanent settlements and began the practice of division of labor, it became essential for survival to be accepted as a member of the society and the various groups within it. So the group evolution forced the evolution of cooperative traits which qualified individuals to become members of the established society. In this study, we have looked at a variety of social groups and determined the requirements they place on individual personality structure. The first step was to define personality as an eight-dimensional vector space, extending the theory of "The Psychology of Personal Constructs" developed by George Kelly in the mid-fifties. The second step was to characterize human activities, careers and avocations, as memes according to the same structure. Then we determined the personality axes that were most demanded by the memes. The personality traits which score highest were deemed to be most important and the most influential in guiding human evolution. The presentation will report the results of the analysis and the relative ranking of human personality traits in order of importance. (Received August 14, 2012)

1086-VG-415 **Rebecca Gasper*** (rebecca-gasper@uiowa.edu), The University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242. *Action Potentials in Peripheral Auditory Nervous System: A Novel PDE Distribution Model*. Preliminary report.

Long have speech and hearing pathologists analyzed clinical reaction speeds by constructing histograms (graphs with reaction times sorted into time interval 'boxes'). Their goal is to experimentally model reaction time of a neuron as a function of stimulus strength; understanding signal propagation has applications in Cochlear Implant design and maintenance. Since a popular model for single-node action potential magnitude is known (Hodgkin and Huxley, 1952), we can use numerical methods to create an entire probability distribution of firing times. Mathematically, we transition from a deterministic nonlinear ODE to an advection-diffusion PDE which represents distribution of all the states of ODE variables over time. Using steady-state assumptions or more complicated assumptions such as stochasticity, we show preliminary results to the question "When will a neuron fire and how does the distribution of firing times depend on parameters?" (Received August 30, 2012)

1086-VG-420 **Aaron Rodriguez*** (rodr45@iastate.edu), **Cheri Shakiban** (cshakiban@stthomas.edu) and **Jack Stangl** (stan2984@stthomas.edu). *Characterization of Melanoma and Moles using Fractal Dimension*.

This research focuses on the mathematical detection and analysis of border irregularity in skin lesions for the purpose of identifying malignant melanoma amongst benign moles. In particular, we utilize the method of Fractal Dimension, based on the box counting method. The border irregularity of known malignant melanoma samples are compared to the border irregularity of known nevi, or common moles. We propose that melanoma possess distinguishable border differences from nevi, often undetectable to the human eye. We utilize this mathematical method to detect and quantize this difference to aid in diagnosis. (Received August 30, 2012)

1086-VG-527 **Jack T Stangl*** (jackstangl@yahoo.com). *Characterization of Melanoma and Moles using Invariant Histograms*.

This research is an exploration into mathematical biology, specifically the detection of malignant melanoma amongst benign moles. We propose that melanoma samples possess distinguishable border differences from mole samples, often undetectable to the human eye. We utilize mathematical methods including Invariant Histograms to detect and quantize this difference for diagnosis, looking closely at the irregularity of melanoma and mole sample borders. This approach relies heavily on the generation of cumulative distance histograms and subsequent statistical analysis. (Received September 05, 2012)

1086-VG-581 **Liliana Maritza Alvarez*** (lalvarez2@my.apsu.edu), **Anne Maree French** and **Ramanjit K Sahi**. *Stochastic Applications of Knots and Literature*. Preliminary report.

Our presentation demonstrates the various usages of Markov chains. Branching out, Markov chains and stochastic processes have been found to have applications in knot theory. We will study different types of knots created from n- length words in association to Markov chains. Using graph theory as an instrument, we will see the linkage between the world of literature and knot theory. (Received September 07, 2012)

- 1086-VG-771 **Abbas Syed*** (sabbas.iitk@gmail.com), Assistant Professor, School of Basic Sciences, IIT Mandi, H.P., Mandi, 175001, India, and **Lakshman Mahto**. *Fractional model of phytoplankton allelopathy.*

In this work, we investigate the fractional model of two interacting phytoplankton species in which one species is producing a chemical which stimulate or reduce the growth of other species. I will use the concept of Caputo's fractional derivative. After establish existence, uniqueness and stability analysis, we do numerical simulation too to validate our analytical finding. (Received September 12, 2012)

- 1086-VG-858 **Joon Hyuk Kang*** (kang@andrews.edu), Department of Mathematics, Andrews University, Berrien Springs, MI 49104. *Existence and Uniqueness of steady state solution for a general population model.*

Multiple species of animals are competing in the same environment. Under what conditions do they coexist peacefully? Under what conditions do they coexist in a unique pattern? Or under what conditions does either one of the species become extinct, that is, is either one of the species excluded by the other? It is natural to say that they can coexist peacefully if their rates of reproduction and self-limitation are relatively larger than those of competition rates. In other words, they can survive if they interact strongly among themselves and weakly with others. We investigate this phenomena in mathematical point of view.

There are a lot of results regarding the questions I raised up in the simple Lotka-Volterra population model with linear growth rates. We develop their results to more generalized model.

The techniques used are elliptic theory, upper-lower solutions, maximum principles and spectrum estimates. The arguments also rely on some detailed properties for the solution of logistic equations. (Received September 14, 2012)

- 1086-VG-864 **Badal Joshi*** (joshi@umn.edu), joshi@umn.edu, and **Mainak Patel**. *Stochastic switching and alternating activity bouts resulting from mutual inhibition and applications to sleep-wake cycling in mammals.*

'Sleep-active' and 'wake-active' neurons in the brains of mammals are thought to inhibit each other resulting both in discrete states of sleep and wake and switching between the two states. New behavioral data sheds light on the underlying neurophysiology. In infants, both sleep and wake bout durations have an exponential distribution with independent regulation of bout means. This suggests stochastic switching in a bistable system, and so we modeled this system as a pair of coupled, mutually inhibitory neurons receiving noisy driving currents. We examined bout durations of the two neurons, switching mechanisms, and dependence on system parameters. Regardless of parameter choices, we found that bout durations of a neuron are always exponentially distributed. Furthermore, bout switches were found to be primarily a consequence of release from inhibition rather than escape via excitation, and we found that inhibition allows independent control over bout lengths of the two neurons. (Received September 18, 2012)

- 1086-VG-912 **Folashade B Augusto*** (fbagusto@gmail.com), Department of Mathematics & Statistics, Austin Peay State University, Clarksville, TN 37044. *Malaria Drug Resistance: The impact of Human Movement and Spatial Heterogeneity.* Preliminary report.

Human habitat connectivity, movement rates and spatial heterogeneity have tremendous impact on the effectiveness of malaria control and eradication. In this paper, a deterministic system of differential equations for malaria transmission in a two patch system that incorporates human movements and the development of drug resistance malaria is presented. The impact of movement between the patches is determined by qualitative analysis of the model basic reproduction number. Sensitivity analysis is performed on the key parameters that drive the disease dynamics of the model in order to determine their relative importance to disease transmission and control within and between patch. (Received September 16, 2012)

- 1086-VG-1071 **Seda Arat*** (sedag@vt.edu), 460 McBryde Hall, Department of Mathematics, Blacksburg, VA 24060, and **George Bullerjahn** and **Reinhard Laubenbacher**. *A Mathematical Model of Denitrification Metabolic Network in Pseudomonas aeruginosa.*

Lake Erie is one of the Great Lakes in North America and has a favorable environment for agriculture in which nitrate (NO_3) is widely used as fertilizers. For decades, Lake Erie has witnessed recurrent summertime low-oxygen dead zones and related microbial production of greenhouse gases such as nitrous oxide (N_2O). In fact, N_2O is an intermediate in complete denitrification, which is a microbial process of reduction of nitrate (NO_3) to nitrogen gas (N_2) via nitrogen oxides. We present a denitrification metabolic network as a discrete model for *Pseudomonas aeruginosa*, one of the taxa performing denitrification in Lake Erie. We analyze the long run behavior of the system by changing the concentration level of oxygen (O_2), nitrate (NO_3) and phosphate (PO_4).

This work suggests that PO_4 highly affect the behavior of the network by inhibiting the major regulator of the system. (Received September 18, 2012)

- 1086-VG-1282 **Muna A Alhalawa*** (muna.alhalawa@ist.utl.pt), Technical University of Lisbon, lisbon, Portugal, **Saber Elaydi** (saber.elaydi@trinity.edu), Trinity University, San Antonio, Texas, san antonio, TX 78212, and **Henrique Oliveira** (holiv@math.ist.utl.pt), Technical University of Lisbon, 78212 lisbon, Portugal. *Stability and bifurcation of a three dimensional Ricker model.*

In this talk we focus on the Ricker competition model of three species. We present an analysis of the stability and local bifurcation of the fixed points. Our exploration of the dynamics of this system begins with the symmetric case and ends with the general case. (Received September 20, 2012)

- 1086-VG-1358 **Angela Angeleska*** (aangeleska@ut.edu), **Sabrina Kleessen** and **Zoran Nikoloski**. *The Sequence Reconstruction Problem as an Integer Programming Problem.* Preliminary report.

Assembly of genomes from high-throughput data generated by the Next Generation Sequencing (NGS) technologies remains one of the most challenging tasks in modern biology. Here we address the Sequence Reconstruction (SR) problem whereby, for a given collection of subsequences or factors, one is to determine the set of sequences compliant with the collection. First, we give an overview of the SR problem from a language-theoretic perspective, and present the advantages and shortcomings of the existing algorithmic approaches. We then propose an optimization-based formulation, which casts the SR problem as a quadratic integer program whose solutions can be enumerated with appropriate transformations. This approach is relevant for the genome assembly problem and can be matched with the employed NGS technologies. (Received September 21, 2012)

- 1086-VG-1491 **Najat Ziyadi*** (najat.ziyadi@morgan.edu), Mathematics Department, Morgan State University, 1700 East Cold Spring Lane, Baltimore, MD 21251, and **Said Boulite, M. Lhassan Hbid** and **Suzanne Touzeau**. *Mathematical analysis of a scrapie disease transmission model.*

Scrapie is a transmissible spongiform encephalopathy that affects sheep. We analyse a mathematical model which describes the spread of scrapie in a sheep flock that takes into account various factors and processes, including seasonal breeding, horizontal and vertical transmission, genetic susceptibility of sheep to the disease, and a long and variable incubation period. The model, derived from a classical SI (susceptible-infected) model, also incorporates a discrete genetic structure for the flock, as well as a continuous infection load structure which represents the disease incubation. The resulting model consists of a set of partial differential equations which describe the evolution of the flock with respect to time and infection load. (Received September 22, 2012)

- 1086-VG-1537 **Shishi Z Luo*** (shishi.luo@gmail.com), Department of Mathematics, Duke University, Box 90320, Durham, NC 27708. *A ball-and-urn system for understanding multilevel selection.*

Natural selection can act at multiple biological levels, often in opposing directions. This is particularly the case for pathogen evolution, which occurs both within the host it infects and via transmission between hosts, and for the evolution of cooperative behavior, where individually advantageous strategies are disadvantageous at the group level. In mathematical terms, these are multiscale systems characterized by stochasticity at each scale. We show how a simple and natural formulation of this can be viewed as a ball-and-urn process. This equivalent process has very nice mathematical properties, namely it converges weakly to the solution of an analytically tractable integro-partial differential equation. We then study properties of this limiting object to infer general properties of multilevel selection. (Received September 23, 2012)

- 1086-VG-1543 **Mohamed Allali*** (allali@chapman.edu). *Mathematical modeling for image inpainting.* Inpainting is the process of restoring or correcting photos and painting. In this talk, I will show through imaging inpainting how we can incorporate a practical and interesting problem into mathematics courses. This approach makes the courses more visual and interesting for instructors and students. (Received September 23, 2012)

- 1086-VG-1576 **Qiwei Sheng*** (qiwei-sheng@uiowa.edu). *A numerical method for generalized Fokker-Planck equations.*

Generalized Fokker-Planck (GFP) equations have been employed to approximate the radiative transfer equation in applications of highly forward peaked biological media. In this talk, we discuss a numerical method for solving GFP equations. The numerical method is based on a variational formulation involving even and odd components of the solution. We show the well-posedness of the variational formulation and develop a Galerkin

method where spherical harmonics are used for the angular approximation and finite elements are used for spatial discretization. Finally, an iteration procedure is introduced to solve the problem and its convergence is shown. (Received September 24, 2012)

1086-VG-1589 **Delong Meng*** (delong13@mit.edu), 290 Massachusetts Ave, Cambridge, MA 02139. *Top Trading Cycle with Random Student Preferences.*

The top trading cycle is a mechanism used in many school districts to assign students to public schools. The mechanism has many desired properties such as Pareto-efficiency and strategy-proof-ness, but for practical application one major problem is to determine the most fair way to assign each student a lottery number. Previous research have shown that certain classes of lottery systems are equivalent in some special cases. In this talk I will present an equivalence theorem for the general case, i.e., when schools have arbitrary priority groups over students. In particular I will show that under stochastically generated student preferences all lottery systems yield the same social welfare. I will also compare my theoretical result with data from the 2008 Boston Public School Match and discuss some possible limitations of my model. (Received September 23, 2012)

1086-VG-1605 **Emarus Danielle Shay*** (eshay@my.apsu.edu), 2414 Peachers Mill Rd, Clarksville, TN 37042, and **Ramanjit K Sahi.** *A Frozen Pattern in Time.* Preliminary report.

Since the 15th century, the traditional weaving in the form of phulkari reflects the heart and beauty of the Punjabi culture. These geometrical patterns in phulkari are symmetrical in nature and exhibit rotational symmetry patterns, frieze patterns, and plane patterns. In this presentation we will talk about how frieze patterns occur in phulkari. The analysis of frieze patterns can be very helpful in tracing the relationships between different cultures and mathematics. (Received September 23, 2012)

1086-VG-1620 **Brendan C. Fry*** (bfry@math.arizona.edu), Program in Applied Mathematics, University of Arizona, Tucson, AZ 85721, and **Timothy W. Secomb,** Department of Physiology, University of Arizona, Tucson, AZ 85721. *Theoretical model for metabolic blood flow regulation in a heterogeneous microvascular network.*

Blood flow in the microcirculation is regulated according to local metabolic demands of the tissue; however, the mechanism for this regulation is not entirely known. The purpose of this investigation is to analyze the effects of metabolic flow regulation by signals derived from red blood cells (RBCs), from the vessel wall, and from surrounding tissue, in response to changes in oxygen (O₂) demand and delivery. A theoretical model is used to simulate blood flow, O₂ transport, and flow regulation in microvascular networks with realistic heterogeneous structures. If O₂ demand is increased or O₂ delivery is decreased, the initial effects are increased regions of poor tissue oxygenation. If the metabolic signal is assumed to originate solely from a RBC-dependent mechanism, the model predicts that flow regulation will cause a reduction in blood flows and further worsening of tissue oxygenation. If the metabolic signal is assumed to originate instead from a wall- or tissue-dependent mechanism, flow regulation causes an increase in flow, resulting in improved tissue oxygenation. These findings suggest that a RBC-independent mechanism of metabolic blood flow regulation is required for an appropriate physiological response to changing O₂ demand and delivery. NIH grant HL070657. (Received September 23, 2012)

1086-VG-1777 **Yanyan He*** (yhe2@math.fsu.edu), 307 Pennell Circle, Apt. 1, Tallahassee, FL 32310, and **Yousuff Hussaini.** *A Comprehensive Approach of Data Fusion based on Evidence Theory.* Preliminary report.

Data fusion techniques combine/integrate data from multiple sources (such as models, sensors, institutes, and etc.), to achieve more specific and more accurate inference than that from individual ones. In this presentation, a comprehensive approach based on evidence theory is proposed to combine distinct sources of information with uncertainty involved. Belief functions in evidence theory are used to represent the uncertainty in each source individually and combination rules in evidence theory are used to get a single belief function representing information from all sources. The proposed approach overcomes the challenges of existing combination rules: distinguishing and handling highly conflict sources. And the combined result is optimal in the sense that it contains as much information from individual sources (equally reliable) as possible. Examples are provided to demonstrate the proposed approach. (Received September 25, 2012)

1086-VG-1806 **Daniel S. Munther*** (munther@mathstat.yorku.ca), Department of Mathematics and Statistics, N520 Ross, 4700 Keele Street, Toronto, Ontario M3J1P3, Canada, and **Jianhong Wu.** *Enhanced surveillance on food-borne disease outbreaks: dynamics of cross-contamination in biocidal wash procedure.* Preliminary report.

I will discuss some recent food-borne disease outbreaks associated to fresh produce, present a 3-stage compartment model of the wash process for fresh produce at a processing plant and discuss an application of the model

to *E. Coli* contamination of romaine lettuce. Furthermore, I will talk about how the model can give insight into source diagnoses of the contamination and be used to compare various wash procedures. (Received September 24, 2012)

- 1086-VG-1811 **Eva M. Strawbridge*** (strawbem@jmu.edu), Department of Mathematics and Statistics, James Madison University, Roop Hall, MSC 1911, Harrisonburg, VA 22807, **Yvonne Lai** (yvonnexlai@gmail.com), School of Education, University of Michigan, Ann Arbor, MI 48109-1259, and **Sarah Williams** (saw@email.unc.edu). *Mathematical Modeling as a Means of Intentional Development of Intuition.*

Frequent appeals for teaching mathematical modeling hinge on connections to the real world: accessibility and interest, opportunity for multiple valid solutions, and ability to reason about the world. Yet if students are to capitalize on accessibility and interest to yield viable reasoning and solutions, they need intuition for working with concrete observations as well as abstractions. We discuss experiences creating modules to develop such intuition. We drew from the ideas of (1) a math modeling cycle (e.g., Ferri (2006)) – that modeling can be structured by repeated, systematic inquiry into the real life situation, the situation model, the mathematical model, and the results of each; and (2) mathematization (e.g., Quine (1993)) – “translating” from common to mathematical language. We used our module to teach applications and writing in calculus and ordinary differential equations, as well as in high school extracurricular mathematics activities. We discuss lessons learned, highlighting cases about the fishing industry, the West Nile virus, and passenger pigeons. We share guidelines used for coaching students through the modeling cycle and rubrics for grading work. We hope that this discussion will help others adapt and refine our experiences for their own contexts. (Received September 24, 2012)

- 1086-VG-1812 **Megan E Sawyer***, mesawyer@ncsu.edu. *Compartmentalizing The Sunlight Vitamin: Using PBPK Modeling to explore Levels of Vitamin D and its Metabolites.*

Vitamin D sufficiency has far-reaching health implications in many different systems of the body. Yet, it is the second substance in the metabolism cascade that is actually beneficial. To become active, vitamin D must be metabolized first into 25(OH)D and then into the active form 1,25(OH)2D. Levels of vitamin D and 1,25(OH)2D are hard to accurately measure so predictions of vitamin D sufficiency are made through measuring the concentration of the most stable metabolite, 25(OH)D. This system of cascades yields itself well to analysis through physiologically based pharmacokinetic (PBPK) modeling. PBPK modeling is a compartmental-based technique that accounts for various physical and physiological properties of the substances and the subjects, and allows for testing of various exposure schemes *in silico*. In this talk, we will discuss the development and complexities of the PBPK model for the vitamin D cascade and several results. (Received September 24, 2012)

- 1086-VG-2069 **Mark E Whidden*** (mwhidden@math.fsu.edu), 1017 Academic Way, Love Building, Room 208, Tallahassee, FL 32303. *Numerical Simulations of a Multiphase Model for Biofilm Development.*

In recent years, many biological phenomena involving complex mechanical and biochemical interactions of multiple components have been successfully modeled using a multiphase framework, including tumorigenesis, gel swelling kinetics, and developmental processes. We construct a multiphase model which captures the spatial patterning of the biofilm formation that occurs in Pierce’s Disease, as observed in particular microfluidic experiments. However, the resulting nonlinear, coupled PDE system demands numerical simulations to study its evolution. In this talk, I will examine the computational issues for the numerical simulation of this development of a biofilm, and demonstrate some particular schemes which are both efficient and robust. (Received September 24, 2012)

- 1086-VG-2239 **Nathanial Burch*** (njburch@ncsu.edu), **Levis Eneya** (leneya@cc.ac.mw), **Sean Kramer** (kramersj@clarkson.edu) and **Samantha Tracht** (tracht@math.utk.edu). *The Utility of Transient Sensitivity Analysis for Malaria Intervention Strategies.* Preliminary report.

In this talk, we review so-called transient sensitivity analysis in the context of a compartmental disease model for the transmission of malaria between human and mosquito populations. Such transient sensitivity analyses as this provide information that is synergistic with short-term and adaptive management strategies, while also helping to quantify and understand the effects of uncertainties, e.g., that arise in parameter estimation from noisy data. We derive the sensitivity equations for this model and compare the subsequent results to analogous equilibrium-based sensitivity analyses such as the sensitivity of the effective reproduction number R_0 . Our findings elucidate complicated transient dynamics of malaria transmission, highlight potential effective strategies for the control

and intervention of malaria outbreaks, and provide a tool for uncertainty quantification. (Received September 25, 2012)

1086-VG-2261 **Satyajit Das and Debashree Guha*** (debashree@iitp.ac.in, deb1711@yahoo.co.in). *Application of Intuitionistic Fuzzy Set and Fuzzy Set in Medical Diagnosis.*

In this paper a new attempt has been made for medical diagnosis by utilizing both fuzzy and intuitionistic fuzzy frameworks. For this purpose a medical knowledge base is required. To form the knowledge base five symptoms such as 'Temperature, Headache, Stomach Pain, Cough and Chest Problem' and five diseases such as 'Viral Fever, Malaria, Typhoid, Stomach Problem and Chest Problem' are considered. It is also assumed that the patients' symptoms may take any value on the standard fuzzy scale having five polar terms such as 'Very Low, Low, Medium, High, Very High'. The degree of confidence of the experts for measuring each of these symptoms is inherently involved with each of the aforementioned linguistic terms. Then a medical knowledge base is formed using a set of fuzzy decision rules. The antecedent part of the rules contains linguistic values of the patients' symptoms with different degree of confidence of the experts and the consequent part reveals the degree of association and the degree of non-association between the symptoms and diagnosis. Now a set of n patients is considered. For each patient a set of symptoms is given. In these situations, appropriate fuzzy reasoning scheme is used to determine a proper diagnosis for each patient with the given values of tested symptoms. (Received September 25, 2012)

1086-VG-2262 **Muhammad Irfan Hameed*** (mhameed@uscupstate.edu), Division of Mathematics & Computer Science, USC UPSTATE, 800 University Way, Spartanburg, SC 29303. *Breakup of an extending particle-laden liquid jet.*

A mathematical model is derived to study the effect of solid particles for an extending liquid jet. Governing equations for the dynamics are derived for Stokes flow using long wavelength assumptions for the capillarity-driven flow, and the influence of the force-free particle is represented by a symmetric hydrodynamic force dipole. The theoretical calculations based on this hybrid long wavelength and singularity approach yield qualitatively accurate and encouraging agreement with experimental observations. Results are presented for one particle centered or off-center (with respect to the period of the jet) and for two particles. (Received September 25, 2012)

1086-VG-2351 **Jun-Koo Park*** (jun-koo.park@houghton.edu), One Willard Ave., Houghton, NY 14744. *On coarse-grained Normal Mode Analysis and refined Gaussian Network Model for protein structure fluctuations.*

Functions of bio-structures are related to the dynamics, especially various kinds of large-amplitude motions. With some assumptions, those motions can be investigated by Normal Mode Analysis and Gaussian Network Model. However, despite their contributions to many applications, the relationship between NMA and GNM requires a further discussion. In this work, we review the NMA and GNM and evaluate GNM, based on how well it predicts the structural fluctuations, compared to experimental data. Then, we propose ways of coarse-graining for NMA on protein residue-level structural fluctuations by choosing different approaches to represent the amino acids and the forces between them. The residue mean-square-fluctuations and their correlations with the experimental B-factors are calculated for a large set of proteins. The coarse-grained methods perform more efficiently than all-atom normal mode analysis, and also agree better with the B-factors. B-factor correlations are comparable or better than with those estimated with conventional GNM. The extracted force constants are surveyed for different pairs of residues with different extents of separation in sequence. The statistical averages are used to build a finer-grained GNM, which is able to predict fluctuations better than GNM. (Received September 25, 2012)

1086-VG-2455 **Eric P. Choate*** (echoate@nps.edu). *Stability of the homeotropic orientation in the optical Fredericks transition of a liquid crystal layer.*

The orientation of a liquid crystal in the absence of an electromagnetic field is determined by hard-wall anchoring conditions. However, the application of an electromagnetic field, such as a light wave, causes the liquid crystal to align with the field if the field is above a critical intensity, a phenomenon known as the Frederiks transition. The wave is commonly assumed to be unaffected by the liquid crystal reorientation, but the reorientation does change the anisotropy of the liquid crystal medium as the wave passes through it, which in turn affects the wave propagation. We examine the nonlinear optics problem of coupling the liquid crystal orientation and the electromagnetic field for a normally incident plane wave passing through a liquid crystal layer between two parallel plates with homeotropic anchoring conditions so that the orientation of the layer is perpendicular to the plates in the absence of the field. Using a combination of analytical and numerical techniques, we minimize

the free energy of the liquid crystal system and estimate the critical field strength at which the homeotropic orientation becomes unstable. We also briefly examine the stability of the non-homeotropic solution for stronger fields and the possibility of hysteresis. (Received September 25, 2012)

1086-VG-2492 **Edmond J. Nadler*** (nadler@alum.mit.edu) and **Tae-wan Kim**. *Singularity of Cubic Bézier Curves and Surfaces*.

Parametric cubic polynomial curves and surfaces are useful in applications, being of relatively low dimension, and yet, flexible in their shape. To use these curves and surfaces fully, one must completely understand the cases of singularity. A parametric curve is singular where its derivative is zero, and a parametric surface, where its normal vector is zero.

These singularities are described here in terms of the Bézier form, a representation of parametric polynomial curves and surfaces employing the Bernstein polynomials as basis functions, in which the coefficients have geometric significance. Bézier curves and surfaces, which are used extensively in computer graphics, computer-aided design, and related fields, were first developed in the 1950s and 60s in the French automobile industry. (Received September 25, 2012)

1086-VG-2595 **Michael A Robert*** (marober5@ncsu.edu), North Carolina State University, Box 8203, Raleigh, NC 27695, and **Fred Gould** and **Alun L Lloyd**. *Optimizing a female-killing strategy to control the dengue vector, Aedes aegypti*.

Dengue fever is spread primarily by the mosquito, *Aedes aegypti*. Although traditional control measures have been implemented for many years, dengue remains endemic in many parts of the world. In recent decades, novel control strategies involving the release of genetically modified mosquitoes have been proposed. Among those for *Ae. aegypti* that have garnered the most attention are Female-Killing (FK) strategies. Recent cage experiments showed that repeated introductions of individuals from one FK strain of *Ae. aegypti* led to either reduction or extinction of caged wild-type populations, and open field releases of FK individuals are becoming more feasible. Releases should be conducted according to strategies that take into account possible temporal and financial constraints. We develop an optimal control model to assess the role that such constraints will play in conducting FK releases. Through numerical simulation, we obtain optimal release strategies for a variety of scenarios. We also assess the feasibility of combining FK releases with other forms of vector control and obtain optimal strategies for integrated approaches to controlling *Ae. aegypti*. With the results of our study, we assess the impacts that the optimal strategies could have on dengue fever. (Received September 25, 2012)

1086-VG-2695 **Justin Y Sunu** (justinsunu@gmail.com), 19721 Lancewood Plaza, Yorba Linda, CA 92886, and **Torin A Gerhart*** (toringergart@gmail.com), 13640 Lemay St., Van Nuys, CA 91401. *Clustering Methods to Detect Gas Plumes in Hyperspectral Images*. Preliminary report.

Automated detection of chemical attacks presents a huge challenge in modern society due to the undiscerning nature of the gas cloud. The advantage of considering hyperspectral images in the gas plume detection problem over the conventional RGB imagery is the presence of nonvisual data, allowing for a richer representation of information. In this work, we will demonstrate how the method of spectral clustering as well as the Ginzberg-Landau functional can be utilized to detect gas clouds that are derivatives of various chemical make-ups. Empirical results obtained on a Long-wave Infrared (LWIR) spectral data provided by the Applied Physics Lab at the Johns Hopkins University outperformed the included benchmarking algorithm (Adaptive Matched Subspace Detection Algorithm) and show clear separation of the gas plume against the background. (Received September 25, 2012)

1086-VG-2919 **Cory C Heid*** (cheid@sienaheights.edu), 1247 E. Siena Heights Drive, Adrian, MI 49221. *How Many Licks to the Tootsie Roll center to a Tootsie Pop?* Preliminary report.

A model is proposed to address the burning question, "How many licks does it take to get to the center of a Tootsie Roll Pop?". The model incorporates the dissolve rate of Tootsie Pop in saliva with a simulated licking force. Simulated data will be used to determine factors most significantly affecting the dependent variable. A multiple regression model is being proposed. Various factors being involved are: the solutions, stir speeds and temperature. A model that evaluates the data collected will predict the number of licks required to find the Tootsie Pop center. (Received September 26, 2012)

1086-VG-2976 **Shane Ryerson***, 3222 Verano Place, Irvine, CA 92617, and **German Enciso**. *Ultrasensitivity for Graded Multisite Activation Networks*.

Multisite protein modification is widely recognized as an essential feature of many switch-like dose responses. It is usually assumed that cooperativity is involved, i.e. the ability of one modified site to alter the rate of modification of its neighbors. We make a very different set of assumptions to obtain ultrasensitive behavior,

namely that the individual sites are identical and independent of each other, and that the protein activity is an arbitrary increasing function of the number of modified sites. Under these assumptions we provide theoretical estimates of the Hill coefficient of the dose response. Examples are provided along with numerical simulations for biochemical reaction network models of bacterial chemotaxis and the yeast pheromone pathway. (Received September 26, 2012)

General Session on Probability and Statistics

1086-VI-95 **Andrew Niedermaier*** (aniedermaier@janestreet.com), 1 New York Plaza, 33rd Floor, New York, NY 10004. *The Power Law, or: Just Your Everyday 25-sigma Event...*

If you pick a real-life probability distribution out of a hat, there's a good chance it's related to a normal or log-normal. Or maybe it'll just *seem* that way when you sample it a handful of times.

But what if it wasn't normal at all, and you thought it was? And what if you then went out and traded trillions of dollars worth of securities based on your incorrect model?

Well, before we get *that* far, I'd like to talk about the Power Law for a little while: how it differs from the normal distribution, where it crops up, and what it can teach those of us in finance about the price of overconfidence.

I'll also touch on solar flares, Dow Jones, and Twilight. Naturally. (Received July 15, 2012)

1086-VI-371 **Salam Md. Mahbubush Khan*** (khan@math.fsu.edu), Alabama A&M University, 4900 Meridian Street, Normal, AL 35762. *Approximation of the Generalized Poisson Distribution.*

The generalized Poisson distribution is a three parameter distribution. This distribution is becoming increasingly useful in many branches of science specially related to single-server steady state queueing processes. Generalized distributions are becoming increasingly evident and useful in many branches of science but the functional forms of these generalized distributions are often complicated. Therefore, there arises a need to have some simplified or approximated form of this generalized distribution and also to know their relations with other distributions. Here we approximate the generalized Poisson distribution by using different techniques and suggested the best approximation. We also derive the standard normal approximation of generalized Poisson distribution. The results are intended to fill a conspicuous gap in the mathematical and statistical literature concerning the empirical quality of the approximations, and they are useful for designing efficient and accurate computing algorithms for such probabilities. (Received August 26, 2012)

1086-VI-403 **Cristina Tone*** (cristina.tone@louisville.edu), 328 Natural Sciences Building, Department of Mathematics, University of Louisville, Louisville, KY 40292. *A Central Limit Theorem for Multivariate Strongly Mixing Random Fields.*

We introduce a central limit theorem for strictly stationary random fields of random vectors satisfying the strong mixing condition, in the presence of an interlaced dependence assumption. The result is an extension of Bradley's Corollary 29.33 from "Introduction to Strong Mixing Conditions", Vol. 3, Kendrick Press, 2007. (Received August 29, 2012)

1086-VI-414 **Fei Xing*** (fxing@utk.edu), 227 Ayres Hall, 1403 Circle Drive, Knoxville, TN 37996. *Almost sure asymptotics for Ornstein-Uhlenbeck processes of Poisson potential.*

The objective of this presentation is to study the large time asymptotic of the exponential moment: $\mathbb{E}_x \exp \left\{ \pm \int_0^t V(X(s)) ds \right\}$, where $\{X(s)\}$ is a d -dimensional Ornstein-Uhlenbeck process and $\{V(x)\}_{x \in \mathbb{R}^d}$ is a homogeneous ergodic random Poisson potential. It turns out that the positive/negative exponential moment has e^{ct} growth/decay rate, which is different from the Brownian motion model studied by Carmona and Molchanov in 1995 for positive exponential moment and Sznitman in 1993 for negative exponential moment. (Received August 30, 2012)

1086-VI-417 **Anna V Little*** (alittle2@ju.edu), **Mauro Maggioni** and **Lorenzo Rosasco**. *Estimating the Intrinsic Dimension of High-Dimensional Data Sets.*

This talk introduces a novel approach for estimating the intrinsic dimension of noisy, high-dimensional point clouds. A general class of sets which are locally well-approximated by k dimensional planes but which are embedded in a $D \gg k$ dimensional Euclidean space are considered. The dimension is estimated via a new multiscale algorithm that generalizes principal component analysis (PCA). The classical PCA approach recovers the dimension when the data is linear but fails when the data is non-linear, overestimating the intrinsic dimension.

This new multiscale algorithm exploits the low-dimensional structure of the data, so that its power depends on k rather than D , and is robust to small sample size, noise, and non-linearities in the data. (Received August 30, 2012)

- 1086-VI-499 **Jeremy F Entner*** (jentner@syr.edu), Syracuse University, 215 Carnegie, Mathematics Department, Syracuse, NY 13244, and **Pinyuen Chen**. *Methods of nonparametric selection of the least dispersed of k multivariate populations.*

Given k multivariate populations $\pi_i = \pi(P_i)$ on \mathbb{R}^d , $d > 1$, with absolutely continuous distributions P_i , defined on random variables X_i for $i = 1, \dots, k$, we propose procedures for selecting the "least dispersed" member from a group of k populations. We define our measure of dispersion in terms of the volume of the smallest regions, based on Tukey's halfspace depth, to contain at least p probability. (Received September 05, 2012)

- 1086-VI-500 **Madhu Jain*** (drmadhujain@yahoo.co.in), Department of Mathematics, IIT Roorkee, Roorkee, Hardwar, UT 247 667, India. *Finite Priority Queueing System with Service Interruption.*

This paper is concerned with a finite buffer queueing model with preemptive resume priority and service interruption. The system may fail anytime while providing service to the priority and non-priority customers. The arrival patterns of two types of the customers are independent Poisson processes wherein the service times are exponentially distributed. The service discipline of the customers is first come first served (FCFS) within their own queue. Further, Runge-Kutta (R-K) method of fourth order is used to obtain the solution of the system of transient equations governing the model. Various performance measures are obtained in terms of transient probabilities such as expected number of the customers in the system, throughput, expected delay, probability of the server being idle, busy or broken down, etc.. The numerical results are obtained by taking an illustration to examine the effects of various system parameters on the performance measures and total expected cost. (Received September 05, 2012)

- 1086-VI-519 **Martial Longla*** (longla_m_martial@yahoo.com), 203 Erkenbrecher Ace, Apt 2, Cincinnati, OH 45229, and **Costel Peligrad** and **Magda Peligrad**. *On Functional CLT for reversible Markov chains with nonlinear growth of the variance of partial sums.*

In this paper we study the functional central limit theorem for stationary Markov chains with self-adjoint operator and general state space. We investigate the case when the variance of the partial sum is not asymptotically linear in n , and establish that conditional convergence in distribution of partial sums implies functional CLT. The main tools are maximal inequalities that are further exploited to derive conditions for tightness and convergence to the Brownian motion. (Received September 05, 2012)

- 1086-VI-976 **R M Al-Aqtash*** (alaqt1rm@cmich.edu). *On Generating New Generalized Distributions Using the Logit Transformation.*

A new family of distributions is defined by combining two continuous distributions through logit transformation. A member of this family, the Gumbel-Weibull distribution is studied in detail. Some properties, including shapes, modality, moments, skewness, and kurtosis, and applications to some real world data will be presented. (Received September 17, 2012)

- 1086-VI-977 **Jason J. Moliterno*** (molitiernoj@sacredheart.edu), Department of Mathematics, Sacred Heart University, 5151 Park Avenue, Fairfield, CT 06825-1000. *Visualizing Distributions in a Probability & Statistics Class.*

In an undergraduate Probability & Statistics class, students learn about many types of distributions, both discrete and continuous. In this talk, I discuss three projects that I give to my students which give students the opportunity to visualize, compare, and analyze these distributions. We begin with an Excel project on discrete distributions in which students produce histograms of the binomial, negative binomial, and Poisson distributions. Students are asked to write an analysis comparing the histograms produced when various probabilities are inputted. We then move on to continuous distributions in which the project focuses on the exponential distribution and its comparison to the Poisson distribution. Finally, students do a Maple project on joint distributions which enables them to visualize probability scenarios involving more than one variable. These projects are an opportunity for students to enhance their analytic and writing skills. (Received September 17, 2012)

- 1086-VI-1004 **Abeer Hasan*** (statlover0.05@hotmail.com), 853 Napoleon Rd, Apt 9, Bowling Green, OH 43402. *Flexible Families of Skew T Distributions with Applications.* Preliminary report.

Skew t distributions outperform the skew normal distribution in fitting fat tailed data and provide a promising alternative to model financial and environmental data. In this talk I will present a new approach to generate a

more flexible family of skew t distributions. Some theoretical properties of the resulting family of distributions will be discussed, and some examples of applications in data analysis will be presented. The multivariate form of this distribution will be discussed briefly with some results on special cases of the parameters. Finally, I will talk about more generalized forms of skew t distributions that can be used to fit data.

Abeer Hasan (Received September 17, 2012)

1086-VI-1068 **Marian Frazier*** (frazier.149@osu.edu) and **William I. Notz** (win@stat.osu.edu). *Adaptive Design for Non-Stationary Surfaces Using Changes in Slope.*

Computer experiments are used to study physical processes that are too costly, difficult, or dangerous to experiment with in the physical world. Complex computer code that simulates these physical experiments often results in an extremely long running time. Hence, the design points must be chosen carefully and intelligently. An efficient design method that can investigate the response surface in a small number of samples is a must. With this in mind, sequential (adaptive) designs that allow users to focus their attentions on interesting areas of the response are a logical choice.

Historically, computer experiments included an assumption of stationarity, but new modeling methods have been shown to be effective at fitting non-stationary surfaces. We propose a sequential design method that is efficient at investigating non-stationary response surfaces. This method focuses on the search for areas with large changes in slope, with the idea that sudden changes in slope are an indication of non-stationary “breaks” in the response. While seeking out these boundary points, our method still achieves an effective fit of the entire response surface. The merits of this method are exhibited in several examples, including comparisons to existing sequential design methods. (Received September 18, 2012)

1086-VI-1269 **Brianna C Heggeseth*** (bhirst@stat.berkeley.edu). *Comparison of clustering methods for longitudinal data.*

We consider the problem of clustering longitudinal data to discover discrete groups of individuals with similarly shaped trajectories over time. Researchers naturally interpret clustering results by describing the rate of change and curvature of the representative curves; however, currently available methods are not designed to cluster individuals explicitly by shape. We propose methods to address this issue and compare them to standard clustering methods in simulation and in data applications. (Received September 20, 2012)

1086-VI-1298 **Eric Ruggieri*** (ruggierie@duq.edu), Dept. of Mathematics and Computer Science, Duquesne University, Pittsburgh, PA 15282. *A Bayesian Approach to Detecting Change Points in Climatic Records.*

Given distinct climatic periods in the various facets of the Earth’s climate system, many attempts have been made to determine the exact timing of ‘change points’ or regime boundaries. However, identification of change points is not always a simple task. A time series containing N data points has approximately N^k distinct placements of k change points, rendering brute force enumeration futile as the length of the time series increases. Moreover, how certain are we that any one placement of change points is superior to the rest? In this talk, I’ll introduce a Bayesian Change Point algorithm which provides uncertainty estimates both in the number and location of change points through an efficient probabilistic solution to the multiple change point problem. To illustrate the algorithm, I’ll talk about its application to the NOAA/NCDC annual global surface temperature anomalies time series which has been cited as evidence of global warming. (Received September 20, 2012)

1086-VI-1299 **Grace Ngunkeng*** (ngrace@bgsu.edu), Department of Mathematics and Statistics, Bowling Green State University, Bowling Green, OH 43403, and **Wei Ning** (wning@bgsu.edu), Department of Mathematics and Statistics, 409 Math Science Building, Bowling Green State University, Bowling Green, OH 43403. *An Empirical Likelihood Ratio Based Goodness-of-Fit Test for Skew Normal Distributions.*

In this paper, an empirical likelihood ratio based goodness-of-fit test for skew normal distribution is proposed. The asymptotic null distribution and the alternative distribution are investigated. Simulations indicate that the proposed test can control the type I error within a given nominal level, and it has competitive power compared to the other available tests. Such a proposed test is applied to a real data to illustrate the testing procedure. (Received September 20, 2012)

1086-VI-1434 **Ahmad M Alzaghal*** (alzag1am@cmich.edu), Central Michigan University, Mount Pleasant, MI 48859. *Exponentiated Weibull-Exponential Distribution: Some Properties and Applications.*

A new family of distributions called exponentiated T-X distribution is defined. A member of the family, namely, the Exponentiated Weibull-Exponential distribution is defined and studied. Some of its properties including

distribution shapes, special cases, moments, modes, entropy, skewness and kurtosis are discussed. Applications to real world data are also provided. (Received September 21, 2012)

1086-VI-1484 **Janfeng Zhang, David J. Olive and Ping Ye*** (yepi@quincy.edu), 3010 Fox Run W, Quincy, IL 62301. *Robust Covariance Matrix Estimation with Canonical Correlation Analysis.*

This paper gives three easily computed highly outlier resistant robust \sqrt{n} consistent estimators of multivariate location and dispersion for elliptically contoured distributions with fourth moments. When the data is from a multivariate normal distribution, the dispersion estimators are also consistent estimators of the covariance matrix. Outlier detection and robust canonical correlation analysis are presented as applications. (Received September 22, 2012)

1086-VI-1520 **Arulalan M Rajan***, perarulalan@gmail.com, and **Vittal Rao, Ashok Rao and H S Jamadagni.** *$2\varphi + 1$ and Fibonacci Sequence.*

The classical Fibonacci sequence is known to exhibit many fascinating properties and many constants are associated with it. For example, the limit of the ratio of successive elements of the Fibonacci sequence converges to the golden ratio, φ . It was proved recently that the growth rate of the random Fibonacci sequence is the number 1.1319882487943. In this paper, we look at the classical Fibonacci sequence from a different perspective and associate with it, another constant, $2\varphi + 1$. This corresponds to the limit of variance of the discrete probability distribution that one can generate with the classical Fibonacci sequence. It turns out that this value is also the upper bound on the limit variance of probability distributions induced by not only second order linear recurrence relations with positive integer coefficients, but also, any k^{th} linear recurrence relation with positive integer coefficients. We show that the largest positive real root of such recurrence relation determines the variance. In addition, we also prove that the largest positive real root influences the location of maximum in the sequence obtained from the self linear convolution of the recurrence relation. (Received September 23, 2012)

1086-VI-1608 **George Dr Mytalas*** (mytalas@aub.gr), New York, NY, and **Michael Dr Zazanis,** Greece. *Reliability of a two class k -out-of- n system with repair.*

In this paper we derive the reliability of a system which consists by two independent set of components with finite population n_i for $i = 1, 2$ and a single repair machine. Life times of components are independent exponentially distributed random variables with parameter λ_i . Each of the sets fails the moment the number of functional components falls to $k_i - 1$. One may consider system, as extension of a k -out-of- n system with repairs where we assume two set of components $i = 1, 2$. The system operates under the (N_1, N_2) -policy, meaning that server activated for exhaustive repairs as soon as the number of failed components in set i reaches N_i ($1 \leq N_i \leq n_i - k_i$) for $i = 1, 2$. The repaired components are assumed to be as good as new. The repair times of components and the life times are assumed to be independent of each other. Reliability of the system is computed for different modifications of the model and several other system characteristics are derived. (Received September 23, 2012)

1086-VI-1796 **YUTING HSU*** (yzt1@psu.edu). *Statistical Analysis of Firm Interdependence Using Duration Data—Semiparametric Approach.* Preliminary report.

“Does the pioneer in an industry have a better chance to survive than its competitors?” We formulate a probability model to analyze the problem using right-censored data as follows. A new product first enters the market as the monopolist and later experiences the competition when the similar product is introduced to the market by another company. The main interest is to estimate the distribution of the survival (monopoly and competition) durations and investigate the impacts of the regressors. We propose a Lehmann model with Frailty and establish distribution-free estimation to verify the validity of the parametric model in the previous analysis and reexamine the relation of the competitive products and the significance of the regressors. (Received September 24, 2012)

1086-VI-1906 **K Kaphle*** (kaflek@gmail.com), **F H Ruymgaart** and **G Gaines.** *A note on testing problem of equality of two covariance operators.* Preliminary report.

Eigenvalues of covariance operators play an important role in analysis of functional data. There are various methods of testing equality of two covariance operators when the eigenvalues are simple. These methods needs to be generalized for covariance operators with multiple eigenvalues. We have derived probabilistic results for random perturbations of a covariance operator with eigenvalues of unknown multiplicities. Statistical applications of these results relating to the testing problem will be discussed. (Received September 24, 2012)

- 1086-VI-2128 **Chester Ivan Ismay*** (chester.ismay@gmail.com) and **Randall Eubank** (randall.eubank@asu.edu). *Testing Independence of Parallel Pseudorandom Number Streams: Incorporating the Data's Multivariate Nature.*

Many Monte Carlo applications require that the different streams of random numbers created using parallel processors be independent of each other in a probabilistic sense. Unfortunately, pseudorandom number streams generated in parallel often do not exhibit this characteristic. The TestU01 software package is the standard testing suite for detecting this stream dependence and other properties that make certain pseudorandom generators ineffective in serial or parallel settings.

TestU01 has two methods for testing parallel generated streams. The first turns the parallel generated streams into one vector and runs the standard serial testing procedures on this concatenated stream. The second applies serial tests to the individual streams and then tests the resulting ϕ -values for uniformity. Each technique fails to fully address the multivariate nature of the data. As a consequence of this, we are able to show that some of the data's potential correlations are missed by both of these techniques. We intend to investigate three different methods to better detect inter-stream dependencies: pairwise correlation, multivariate tests of independence, and vector time series tests for white noise. (Received September 25, 2012)

- 1086-VI-2204 **FARZAD SABZIKAR*** (sabzika2@stt.msu.edu), Department of Statistics and Probability, Michigan State University, 619 Red Cedar Road, C512 Wells Hall, East Lansing, MI 48824-1027, and **Mark M Meerschaert** (mcubed@stt.msu.edu), Department of Statistics and Probability, Michigan State University, 619 Red Cedar Road, C430 Wells Hall, East Lansing, MI 48824-1027. *Tempered Fractional Brownian Motion*. Preliminary report.

Tempered fractional Brownian motion TFBM modifies the power law kernel in the moving average representation of a fractional Brownian motion (FBM), adding an exponential tempering. It can be considered as a tempered fractional derivative (or tempered fractional integral) of a Brownian motion. It also has a harmonizable representation. The increments of TFBM are stationary, and the autocovariance of the resulting tempered fractional Gaussian noise TFGN has semi-long range dependence, in which the autocorrelations decay like a power law over a moderate length scale, but eventually fall off more rapidly. The spectral density of TFGN is computed, and a reproducing kernel Hilbert space representation is derived.

Keywords: Fractional Brownian motion, tempered fractional derivative, harmonizable representation, long range dependence, reproducing kernel Hilbert space. (Received September 25, 2012)

- 1086-VI-2295 **George P Yanev*** (yanevgp@utpa.edu), 1201 West University Drive, Department of Mathematics, The University of Texas - Pan American, Edinburg, TX 78539, and **David M Hull** and **Manuel Mota**. *Time to extinction in two-sex branching processes.*

Lower and upper bounds for the cumulative distribution function of the time to extinction in a subcritical two-sex branching process are derived. A recursive approximation procedure is also utilized. The results are illustrated with some simulations. (Received September 25, 2012)

- 1086-VI-2383 **Zengxiang Tong*** (ztong@otterbein.edu), Department of Mathematical Sciences, Otterbein University, Westerville, OH 43081. *Chebyshev and Markov's Inequalities*. Preliminary report.

This paper explores relationships between Markov and Chebyshev's inequalities, and show some of its applications in estimating probabilities. (Received September 25, 2012)

- 1086-VI-2573 **Melody B. Denhere***, Department of Mathematics and Statistics, 221 Parker Hall, Auburn, AL 36849, and **Nedret Billor**, Department of Mathematics and Statistics, 221 Parker Hall, Auburn, AL 36849. *Robust Functional Logistic Regression*.

In this work, we discuss the estimation of the parameter function for a functional logistic regression model. We consider ways that allow for the parameter estimator to be resistant to outliers, in addition to minimizing multicollinearity and reducing the high dimensionality which is inherent with functional data. To achieve this, the functional covariates and functional parameter of the model are approximated in a finite dimensional space generated by an appropriate basis. This approach reduces the functional model to a standard multiple logistic model with highly collinear covariates and potential high dimensionality issues. The proposed estimator tackles these issues and also minimizes the effect of functional outliers. Results from a simulation study and a real world example are also presented to illustrate the performance of the proposed estimator. (Received September 25, 2012)

- 1086-VI-2754 **Chinthaka N Kuruwita*** (ckuruwit@hamilton.edu), Department of Mathematics, Hamilton College, Clinton, NY 13323, and **Colin M Gallagher** and **K B Kulasekera**. *Testing Equality of Nonparametric Quantile Regression Functions.*

This article proposes a new approach for testing the equality of nonparametric quantile regression functions. We use marked empirical processes to develop test statistics that possess good power properties in contrast to available competitors. Finite sample performance of our approach is analyzed through simulations and compared with existing methods under a variety of settings. Two data examples are given that highlights the usefulness of the proposed methodology. (Received September 25, 2012)

- 1086-VI-2797 **Jason Michael Calmes*** (jcalmes@tulane.edu). *Estimating the Probability of Accurate Phylogeny Reconstruction by Quartet Aggregation.*

The reconstruction of phylogenetic trees from biological sequence data is an important and vexing problem for researchers. This problem is not only stochastic rather than deterministic in nature, but verification of any result is almost always impossible, leaving researchers to rely heavily on the strength of their algorithms and estimates of support for their outputs.

To address this limitation of existing approaches, we have developed a method for calculating a probability that is useful in the assessment of phylogenetic accuracy. Given a tree produced from sequences of length n , the probability of the simultaneous reconstruction of all quartets consistent with the tree of interest is estimated.

In this presentation, the technique is introduced on quartets and is then generalized to problems of arbitrary size. Validation for the method is presented in the form of simulation results. (Received September 25, 2012)

- 1086-VI-2798 **Vitaliy S Shvetsov***, Department of Mathematics and Statistics, University of the District of Columbia, 4200 Connecticut Avenue, NW, Washington, DC 20008. *Effect of Potomac River on Salinity in Chesapeake Bay.* Preliminary report.

Water salinity affects weather, ecology and civil infrastructure. The Chesapeake Bay is the largest estuary in the coastal United States. It is a transitional environment between fresh and salt water. As fresh water flow the rivers increases, the salinity of the Bay decreases. High tides bring salt water from the Atlantic Ocean and increase salinity of the Bay. Salt water in the Bay extends deep into the rivers that run into it. The salt water boundary in the rivers is ever changing. In my master's thesis I am analyzing the effect of Potomac River on salinity in Chesapeake Bay. Method: Time series analysis, causal inference. (Received September 25, 2012)

- 1086-VI-2832 **Valbona Bejleri*** (vbejleri@udc.edu), 4200 Connecticut Avenue, NW, Washington, DC, DC 20008. *Asymptotic Behavior of Bayesian Prediction Limits for the Poisson Distribution with an illustration from Tropical Storm Occurrences.*

Bayesian prediction limits for Poisson distribution are obtained by adapting a proper prior from the class of gamma distributions. It is shown that if we consider special flat priors, the derived Bayesian limits will under certain conditions coincide to the frequentist prediction limits. As an illustration, we compare Bayesian and frequentist prediction limits for the tropical storm occurrences. (Received September 25, 2012)

- 1086-VI-2879 **Yu Weng*** (weng@unt.edu), Department of Mathematics, PO BOX 311430, Denton, TX 76203. *Mixed-Frequency Estimation and Regression in Linear and Generalized Linear Models.* Preliminary report.

The rates of convergence and limiting distributions of consistent estimators of parameters in linear regression models and generalized linear models are investigated. The limiting processes which arise are compared against conventional simulation approaches. (Received September 25, 2012)

- 1086-VI-2959 **Guy-vanie M Miakonkana*** (gmm0006@auburn.edu), 221 Parker Hall, Auburn University, Auburn, AL 368349, and **Ash Abebe**. *Rank Based Group Variables Selection in Linear Models.*

We develop a new group variable selection method that removes unimportant groups effectively in linear regression models. The proposed method is based on a penalized rank dispersion function and is robust to outliers in the response direction. We establish the asymptotic normality and the oracle property of the resulting estimator. Numerical studies indicate that our rank-based method performs better than the adaptive lasso for both light and heavy-tailed error distribution. (Received September 26, 2012)

General Session on Research in Algebra and Topology

1086-VJ-88 **Rahim G Karimpour*** (rkarimpour@lindenwood.edu), 2600 W. Main Street, Belleville, IL 62034. *Topological Entropy of Non-Archimedean Topologies.*

A Topology γ on a set X is said to be non-Archimedean Topology if it has a basis β such that if B and B' are two members of β , then either $B \cap B' = \emptyset$ or $B \subset B'$, or $B' \subset B$. If $f : X \rightarrow X$ is continuous and U an open cover of X , then we define $f^{(-1)}(U)$ as the open cover consisting of the inverse image of every element of U ; inductively define f^{-i} for all positive integers i . If we denote the topological entropy of f with respect to U as $\text{ent}(f, U) = \lim_{n \rightarrow \infty} n^{-1} \log(N(U \vee f^{-1}(U) \vee f^{-2}(U) \vee \dots \vee f^{-n+1}(U)))$, where $N(U)$ is the number of sets in a subcover of minimal cardinality and for any two open covering U and V , $U \vee V = \{u \cap v : u \in U, v \in V\}$, then we show that if X is a compact non-Archimedean topological space, then for any homeomorphism $h : X \rightarrow X$ and any open covering U , $\text{ent}(h, U) = 0$.

2000: Mathematics Subject Classification Primary 54F65 Secondary 54H13 (Received July 11, 2012)

1086-VJ-426 **Jesse Tyler Prince-Lubawy*** (jprince1@slu.edu), 1916 Lucas AVE, unit 226, Saint Louis, MO 63103. *Equivalence of Cyclic p^2 Actions on Handlebodies of Genus g .*

We consider all orientation-preserving \mathbb{Z}_{p^2} -actions, where p is prime, on 3-dimensional handlebodies V_g of genus $g \geq 2$. We study the graph of groups (Γ, \mathbf{G}) , which determines a handlebody orbifold $V(\Gamma(\mathbf{v}), \mathbf{G}(\mathbf{v})) \simeq V_g/\mathbb{Z}_{p^2}$. This algebraic characterization is used to enumerate the total number of \mathbb{Z}_{p^2} group actions on such handlebodies, up to equivalence. (Received August 31, 2012)

1086-VJ-674 **Kathryn A Brennen*** (kabrenne@ncsu.edu), 2108 SAS Hall, Box 8205, Raleigh, NC 27606. *Computing the Fine Structure of Symmetric k -Varieties.*

The representation theory of symmetric k -varieties has important applications in many areas of mathematics. Of particular interest is the fine structure of symmetric k -varieties. The fine structure can be described by three invariants. In my work I use tools from algebraic group theory and representation theory to compute and classify two of the three invariants. In the case that the Galois extension to \bar{k} is of order 2, the first of these invariants can be described by a pair of involutions, (σ, θ) , acting on the Lie algebra, which corresponds to an admissible k -involution. For each of these admissible k -involutions, the second invariant can be described by the Weyl-orbits of the k -inner elements, ε , representing pairs $(\sigma, \theta \circ \text{Int}(\varepsilon))$. (Received September 10, 2012)

1086-VJ-738 **Rosanna Mersereau and Michael B. Ward*** (wardm@wou.edu), Mathematics Department, Western Oregon University, Monmouth, OR 97361. *Magic Cayley-Sudoku Tables.* Preliminary report.

A Cayley-Sudoku Table (C-S Table) is the Cayley table of a finite group arranged (unconventionally) so that the body of the Cayley table is divided into blocks containing each group element exactly once, as in a sudoku puzzle. The second author and his students introduced C-S Tables in *Mathematics Magazine* **83** (2010) pp. 130-139. In this talk we introduce Magic C-S Tables in which each block of the C-S Table is a magic square. That is, the (group) sum of the entries in each row, column, and diagonal of each block equals the same fixed group element. Examples, theorems, and open questions suitable for undergraduate investigation are included. (Received September 11, 2012)

1086-VJ-927 **Nathaniel J Schwartz*** (njschwar@ncsu.edu), North Carolina State University, Department of Mathematics, Campus Box 8205, Raleigh, NC 27695. *Involutions of Linear Algebraic Groups over Fields of Characteristic 2.* Preliminary report.

Symmetric k -varieties have applications in several areas of math and physics and are particularly useful in the study of representation theory. Given a linear algebraic group G defined over a field k and θ an involution of G , let H be the fixed point group of θ . Then $G_k(H_k)$ is the set of k -rational points of $G(H)$, and G_k/H_k is called a symmetric k -variety. A first step in better understanding symmetric k -varieties is to study involutions of G . In this talk we describe the isomorphy classes and fixed point groups of involutions of G when k is a field of characteristic 2. (Received September 16, 2012)

1086-VJ-1104 **Christopher Park Mooney*** (christopher-mooney@uiowa.edu), 14 MacLean Hall, Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *τ -Factorization in Commutative Rings with Zero-Divisors.* Preliminary report.

Much work has been done on generalized factorization techniques in integral domains, namely τ -factorization. There has also been substantial progress made in investigating factorization in commutative rings with zero-divisors. This presentation will cover work from an article which synthesizes work done in these two areas by extending the notion of τ -factorization to commutative rings that need not be domains. We define and classify

relations between rings satisfying various τ -finite factorization properties. If time permits, we look into particular types of τ relations, which are interesting when there are zero-divisors present. These particular examples are closely related to zero-divisor graphs. (Received September 18, 2012)

1086-VJ-1119 **Emma M Norbrothen***, Box 8205, 2108 SAS Hall, Raleigh, NC 27695. *Classifying the Double Cosets $H_k \backslash G_k / H_k$ of $SL(2, k)$* . Preliminary report.

Symmetric spaces are defined as the homogenous spaces G/H , where G is a reductive group and H is the fixed point group of an involution θ . These spaces are important in mathematics and physics. Recently the study has expanded to arbitrary fields and these generalizations are called symmetric k -varieties, which are similarly defined as the G_k/H_k , where G_k and H_k are the k -points of G and H , and k is not necessarily algebraically closed.

A problem of importance in number theory and algebraic group theory is to describe the action of H_k on G_k/H_k , which can be seen as the double cosets $H_k \backslash G_k / H_k$. In the Riemannian symmetric space there is the Cartan decomposition $G = HAH$ of the group G , where A is a maximal k -split torus of G . Additionally, in real Riemannian symmetric spaces, all A are H -conjugate. In G_k/H_k , the Cartan decomposition no longer holds and not all A are necessarily H_k -conjugate. Currently I am studying the action of H_k on G_k/H_k for $G = SL(2)$, with an emphasis on the finite and p -adic fields. This is the first step to generalizing double cosets in $SL(n, k)$, quantifying the H_k -conjugacy classes of maximal θ -split tori, and characterizing double cosets. (Received September 19, 2012)

1086-VJ-1141 **Jay R. Stine*** (jstine@misericordia.edu). *A Brief History of Pre-Hausdorff Spaces*.

The classical definition of pre-Hausdorff separation is in terms of separating points by open sets. In this talk we define several functions which are imbeddings of a certain space into a cube, and then describe how these functions can be used to characterize pre-Hausdorff spaces. We will also discuss the origins of these concepts. (Received September 19, 2012)

1086-VJ-1266 **Ik Jae Lee*** (leei@rowan.edu), Department of Mathematics, Rowan University, Glassboro, NJ 08028. *A new generalization of the Khovanov Homology*. Preliminary report.

In this paper we give a new generalization of the Khovanov homology. The construction begins with a Frobenius-algebra-like object in a category of graded vector-spaces with an anyonic braiding, with most of the relations weakened to hold only up to phase. The construction of Khovanov can be adapted to give a new link homology theory from such data. Both Khovanov's original theory and the odd Khovanov homology of Ozsvath, Szabo and Rasmussen arise from special cases of the construction in which the braiding is a symmetry. (Received September 20, 2012)

1086-VJ-1406 **Bryan Charles White***, Department of Mathematics and Statistics, University of New Mexico, Albuquerque, NM 87131. *Star operations on numerical semigroup rings*.

We aim to classify the star operations on conductive numerical semigroup rings which are of the form $k + x^n k[[x]]$. By classifying the star operations on conductive numerical semigroup rings we obtain a better understanding of the set of star operations on general numerical semigroup rings. Here we classify all star operations on the ring $k + x^4 k[[x]]$. We also present several results about general conductive numerical semigroup rings that bring us closer to our goal. (Received September 21, 2012)

1086-VJ-2047 **Michael Landry*** (michaellandry@berkeley.edu) and **MurphyKate Montee** (mmontee@nd.edu). *Knot projections with a single multi-crossing*.

Introduced recently, an n -crossing is a singular point in a projection of a link at which n strands cross such that each strand travels straight through the crossing. We introduce the notion of an übercrossing projection, a knot projection with a single n -crossing. Such a projection is necessarily composed of a collection of loops emanating from the crossing. We prove the surprising fact that all knots have a special type of übercrossing projection, which we call a petal projection, in which no loops contain any others. The rigidity of this form allows all the information about the knot to be concentrated in a permutation corresponding to the levels at which the strands lie within the crossing. These ideas give rise to two new invariants for a knot K : the übercrossing number $\ddot{u}(K)$, and petal number $p(K)$. These are the least number of loops in any übercrossing or petal projection of K , respectively. We relate $\ddot{u}(K)$ and $p(K)$ to other knot invariants, and compute $p(K)$ for several classes of knots, including all knots of 9 or fewer crossings. (Received September 24, 2012)

- 1086-VJ-2052 **Eleanor McNair Abernethy*** (abernethy@math.utk.edu), Department of Mathematics, UTK, 227 Ayres Hall, 1403 Circle Drive, Knoxville, TN 37996-1320. *Gauss Diagram Formulas for Milnor Invariants*. Preliminary report.

I will give a background of Gauss Diagram formulas and their application to Vassiliev Invariants. Gussarov proved that every Vassiliev Invariant has a Gauss Diagram formula (usually not unique) and Polyak and Viro have provided many examples of this. They also showed that the Milnor Invariant on three component links have a Gauss Diagram formula. I will briefly explain this background and then introduce my result of a Gauss Diagram formula for Milnor Invariants on Brunnian (or almost trivial) Links. (Received September 24, 2012)

- 1086-VJ-2259 **Ivan Dungan*** (gdungan@math.fsu.edu). *Algebraic Model of Morphisms between Infinity Group Stacks*. Preliminary report.

We will continue the work of Ettore Aldrovandi's and Behrang Noohi's realization of morphisms between 2-group stacks as butterflies of an algebraic construct, crossed modules, to the infinite case. First, we will produce an algebraic model of infinity group stacks and then formulate the shape of the "weak" morphisms. All of which will be done through homotopical methods. (Received September 25, 2012)

- 1086-VJ-2350 **Aliska L Gibbins*** (gibbins@math.osu.edu), Department of Mathematics, 231 W. 18th Ave, Columbus, OH 43210. *Automorphisms of buildings constructed via covering spaces*.

Buildings were first developed to understand certain classes of groups, but they are beautiful objects in their own right. Loosely, buildings are highly symmetric simplicial complexes. We begin by describing certain spherical buildings and building their geometric realizations. We will use a procedure introduced by Davis in "Examples of buildings via covering spaces" to produce non-spherical buildings from these. We will end by comparing the automorphism groups of the spherical building and the new non-spherical building. (Received September 25, 2012)

- 1086-VJ-2352 **Berit Nilsen Givens*** (bngivens@csupomona.edu), 3801 W Temple Ave, Cal Poly Pomona, Pomona, CA 91768, and **Rebecca Starr**. *On properties preserved by interassociation*. Preliminary report.

Two semigroups (S, \cdot) and $(S, *)$ with the same underlying set are said to interassociate if $a \cdot (b * c) = (a \cdot b) * c$ and $a * (b \cdot c) = (a * b) \cdot c$. Here we consider which properties of semigroups are preserved by interassociation, in the sense that whenever (S, \cdot) has the property, then $(S, *)$ must have the property as well. In particular, we give counterexamples to show that being commutative or being periodic are not preserved by interassociation, along with various conditions under which the properties are preserved. (Received September 25, 2012)

- 1086-VJ-2396 **Joshua Evans Ducey*** (duceyje@jmu.edu), Department of Mathematics and Statistics, 305 Roop Hall, MSC 1911, James Madison University, Harrisonburg, VA 22807. *A Geometric Proof of the Structure Theorem for Finite Abelian Groups*.

Every mathematics major encounters the Fundamental Theorem of Finite Abelian Groups, which states that any finite abelian group is isomorphic to a direct sum of cyclic groups.

In this talk we relate this structure theorem of finite abelian groups to the existence of the Smith normal form of an integer matrix. We then present a geometric proof for both of these facts. (Received September 25, 2012)

- 1086-VJ-2415 **Michael C Fulkerson*** (mfulkerson@uco.edu), 100 N. University Dr., Box 129, Edmond, OK 73034. *Groups with Perfect Order Subsets*. Preliminary report.

A group is said to have perfect order subsets if the number of elements of any given order either divides the order of the group or is zero. In this talk, properties of these groups will be discussed and several new results will be examined. (Received September 25, 2012)

- 1086-VJ-2529 **Elizabeth L. Haynes*** (haynes.elizabeth1@gmail.com). *Smale Flows on Three Dimensional Manifolds*. Preliminary report.

We will discuss how to realize Smale flows on S^3 . We will examine one template, and the possible links and knots formed by the entrance and exit sets. This talk will avoid technical details and present examples, with models. (Received September 25, 2012)

- 1086-VJ-2542 **Linhong Wang*** (lwang@selu.edu), SLU 10687, Hammond, LA 70402, and **Blaise Heider**. *Classification on irreducible representations of the quantum Weyl algebra at roots of unity given by matrices*. Preliminary report.

To describe the representation theory of the quantum Weyl algebra at an l th primitive root γ of unity, Boyette, Leyk, Plunkett, Sipe, and Talley found all nonsingular irreducible matrix solutions to the equation $yx - \gamma xy = 1$,

assuming $yx \neq xy$. We complete their result by finding all irreducible matrix solutions (X, Y) , where X is singular. All irreducible solutions, singular or nonsingular, are classified up to equivalence. (Received September 25, 2012)

1086-VJ-2613 **Matthew J Lennon*** (mj14646@louisiana.edu) and **Gary F Birkenmeier**. *A generalization of the concept of essentiality for rings and module*. Preliminary report.

In this talk the idea of an *intrinsic extension* of a ring, first proposed by Faith and Utumi, is generalized and studied in its own right. This concept can be viewed as a generalization of the well-studied notion of an essential extension of a ring. We also define an analogous notion for modules. Examples and applications are given to demonstrate the usefulness of these ring and module extensions. Specifically, examples are made to functional analysis and group ring theory. (Received September 25, 2012)

1086-VJ-2715 **Xiaohui Shi*** (xiaohuishi@my.unt.edu), Denton, TX 76203. *The Graev Metrics Over Free Groups*.

In this talk I will present for every non-trivial element in free groups, the Graev distances between its positive integer n th power and the identity element is at least n . In particular, this result indicates for every non-trivial element of the free group with two generators, the set of Graev metrics between its n th power and the identity element for all positive integer n is unbounded. This answers a question of Van Den Dries and Gao. Furthermore, this result proves that the new Polish group introduced by Van Den Dries and Gao based on the free group with two generators with the Graev metric has no small groups. (Received September 25, 2012)

1086-VJ-2858 **Benjamin H DeMeo*** (bd2@williams.edu). *Arc Presentations and Grid Diagrams of Multi-Crossing Knots*.

An arc presentation places a knot in a set of half-planes radiating from a central axis so that each half-plane contains a single arc. The grid diagram of a knot, obtained directly from the arc presentation, presents the knot as a set of vertical and horizontal lines lying on an $n \times n$ grid, where n is the number of pages in the arc presentation. We introduce arc presentations and grid diagrams, and discuss further implications in the field of multi-crossing projections and petal projections of knots. (Received September 25, 2012)

1086-VJ-2861 **Alfeen Hasmani*** (ahasmani09@lions.molloy.edu), **Lindsey Hiltner**, **Angela Kraft**, **Daniel Scofield**, **Kirsti Wash** and **Jim Brown**. *Classifying Extensions of a Characteristic p Local Field*.

The classification of extensions of \mathbb{Q}_p has been studied for many years. In particular, Jones and Roberts constructed an online database that identifies finite extensions of \mathbb{Q}_p . For each extension, they describe how to compute various invariants (for example, the Galois group). We extend the results by looking at local fields of characteristic p . In particular, we show how the results are analogous to Jones and Roberts when the characteristic does not divide the degree of the extension. Moreover, following from the work of Pauli and Roblot, we show that the defining polynomials of the totally tamely ramified extensions are generated in a similar manner to the totally tamely ramified extensions of \mathbb{Q}_p . Furthermore, if the characteristic, p , does divide the degree of the extension, we prove that there are infinitely many totally wildly ramified extensions of degree p . (Received September 25, 2012)

1086-VJ-2942 **Dustin J Ross*** (ross@math.colostate.edu), Weber 233, CSU, Fort Collins, CO 80523. *The Gerby Gopakumar-Marino-Vafa Formula*.

We prove a formula for certain cubic \mathbb{Z}_n -Hodge integrals in terms of loop Schur functions. We use this identity to prove the Gromov-Witten/Donaldson-Thomas correspondence for local \mathbb{Z}_n -gerbes over \mathbb{P}^1 . (Received September 26, 2012)

General Session on Research in Analysis

1086-VK-156 **Daniel Sievewright*** (daniel.s.sievewright@wmich.edu). *Deddens Algebras for Weighted Shifts*.

We describe the possible structure of the Deddens algebra associated with a weighted shift, focusing on injective weighted shifts of finite multiplicity. We give necessary and sufficient conditions for such an algebra to have a nontrivial invariant subspace. Then, several examples are given to show that we cannot strengthen the results about the structure of the Deddens algebra. (Received July 30, 2012)

- 1086-VK-434 **Camilo Montoya*** (cmont119@fiu.edu), **Lukas Owens** and **Alexander Basyrov**.
Polarizations of Real Hypersurfaces in \mathbb{C}^n .

Segre varieties and their intersections, known as polarizations, are particular biholomorphic invariants attached to real-analytic hypersurfaces in \mathbb{C}^n . These invariants are studied and used to construct a family of real hypersurfaces in n -dimensional complex space that have a large family of analytic sets with nontrivial polarizations. A result that effectively classifies all hypersurfaces with such family of analytic sets and their polarizations is proven. (Received September 01, 2012)

- 1086-VK-734 **Ekaterina Nathanson*** (ekaterina-nathanson@uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242, and **Laurent Jay** (laurent-jay@uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242. *A Nonlinear Variation of Constants Formula for Integral Equations with Kurzweil-Henstock Integral.*

The method of variations of constants is a well-known method for obtaining solutions to perturbed ordinary differential equation (ODE). The method was first developed for linear ODEs and then generalized by Alekseev for nonlinear ODEs. Most ODEs can be reformulated as integral equations with the Riemann integral. On the other hand integral equations have a larger class of solutions and therefore can be used to model a larger class of problems. The range of described problems can be extended even more by using different kinds of integrals. Our goal is to consider integral equations with the very general one-dimensional Kurzweil-Henstock integral (also known as gauge integral and generalized Riemann integral) and obtain a corresponding nonlinear variation of constants formula. (Received September 11, 2012)

- 1086-VK-1167 **Michelle Craddock*** (michelle.craddock@usma.edu), Department of Mathematical Sciences, 646 Swift Road, Thayer 253, West Point, NY 10996. *Geometric Properties for the Fremlin and Wittstock Tensor Products of Banach Lattices.*

Let X be a Banach lattice and let $1 < p, q < \infty$ such that $1/p + 1/q = 1$. Then $\ell_p \hat{\otimes}_F X$ (respectively, $\ell_p \hat{\otimes}_i X$), the Fremlin projective (respectively, the Wittstock injective) tensor product of ℓ_p and X , is a Grothendieck space if and only if X is a Grothendieck space and each positive operator from ℓ_p (respectively, from ℓ_q) to X^* (respectively, to X^{**}) is compact. (Received September 19, 2012)

- 1086-VK-1362 **Michael A Bishop*** (mbishop@math.arizona.edu). *Ground State of Interacting Boson Systems in Random Potentials.*

The recent experimental realization of Bose-Einstein condensate and the development of techniques in cold atom experiments provide new methods for investigating quantum phenomena and the models that describe them. The Gross-Pitaevskii mean-field approximation is a popular model for describing these interacting boson systems. In this approximation, each particle in the many-particle state is assumed to have the same one-particle state, substituting a linear operator on a large tensor space with a nonlinear operator on a smaller function space. I will discuss a work in preparation with J. Wehr on the ground state of Gross-Pitaevskii mean-field model with local 'soft core' interactions and random potentials. The interplay of interactions and random potentials is unclear: particles localize in systems with random potentials, but repulsive interactions cause states to spread because localization of the entire multi-particle state is energetically expensive. The main result is a criterion for the minimal localization of a mean-field state given its per particle energy and the interaction strength. To help understand this theorem, it will be applied to the model in one discrete dimension with Bernoulli distributed potential. (Received September 21, 2012)

- 1086-VK-1636 **Alrazi M Abdeljabbar*** (abdeljabbara@savannahstate.edu), Savannah State University, Engineering Technology and Mathematics Dpt., 3219 College Street, Savannah, GA 31404. *Determinant Solutions for a (3+1)-Dimensional Generalized KP Equation with Variable Coefficients.*

A system of linear conditions is presented for Wronskian and Grammian solutions to a (3+1)-dimensional generalized vKP equation. The formulations of these solutions require a constraint on variable coefficients. (Received September 23, 2012)

- 1086-VK-2176 **Kate E Ellis*** (keellis@csupomona.edu). *Fractal Strings and Complex Dimensions of Step Functions.* Preliminary report.

Classically, a fractal string is constructed from a bounded open subset of the real line. This fractal string allows one to find a zeta function whose abscissa of convergence is the box counting dimension of the boundary of the open set. In this talk, we will introduce a method which, for a given step function, allows us to define a unique fractal string. This allows us to further define a geometric zeta function and complex dimensions associated with

the step function. Applications of this technique include determining upper box counting dimensions of bounded sets and expressing the counting function as a series over complex dimensions. (Received September 25, 2012)

1086-VK-2179 **Wei-Kai Lai*** (laiw@mailbox.sc.edu), 807 Hampton Street, Walterboro, SC 29488. *Rearrangement Inequality on Positive Tensor Products*. Preliminary report.

In 1934, Hardy, Littlewood and Polya introduced their famous inequality:

$$\sum_{i=1}^m a_i b_{(m+1-i)} \leq \sum_{i=1}^m a_i b_{\sigma(i)} \leq \sum_{i=1}^m a_i b_i,$$

in which the real number sequences $(a_i)_i$ and $(b_i)_i$ are in increasing order, and $\sigma(i)$ indicates a random permutation. In 1974, the injective and (respectively) projective tensor products of Banach lattices were investigated by Wittstock and (respectively) Fremlin. And very soon, these tensor products of Banach lattices were proved to be Banach lattices as well. In this talk, I will use a technique introduced by Bu and Buskes in 2006 to show that if $(a_i)_i$ is a sequence in ℓ_p , and $(b_i)_i$ is a sequence in a random Banach lattice X , we can create a similar version of the rearrangement inequality in Wittstock injective tensor product, $\ell_p \hat{\otimes}_i X$, and Fremlin projective tensor product, $\ell_p \hat{\otimes}_F X$. (Received September 25, 2012)

1086-VK-2622 **Howard S. Cohl*** (hcohl@nist.gov), 100 Bureau Drive, National Institute of Standards and Technology, Gaithersburg, MD 20899-8910. *Generalizations and definite integrals for classical orthogonal polynomials*. Preliminary report.

We generalize generating functions for hypergeometric orthogonal polynomials, namely Wilson, Laguerre, Jacobi, Gegenbauer, Chebyshev, and Legendre polynomials. These generalizations of generating functions are accomplished through series rearrangement using connection relations with one free parameter for these polynomials. We also use orthogonality relations to determine definite integrals. (Received September 25, 2012)

1086-VK-2764 **Yueshi Qin*** (yqin@albany.edu), 29 Niblock Ct, Fl 1, Albany, NY 12206, and **Rongwei Yang**. *A Characterization of Submodules via Beurling-Lax-Halmos Theorem*.

Shift invariant subspaces in the vector-valued Hardy space $H^2(E)$ play important roles in Nagy-Foias operator model theory. A theorem by Beurling, Lax and Halmos characterizes such invariant subspaces by operator-valued inner functions $\Theta(z)$. When $E = H^2(\mathbb{D})$, $H^2(E)$ is the Hardy space over the bidisk $H^2(\mathbb{D}^2)$. This paper shows that for some well-known examples of invariant subspaces in $H^2(\mathbb{D}^2)$, the function $\Theta(z)$ turns out to be strikingly simple. (Received September 25, 2012)

1086-VK-2815 **Jessica Stewart***, jessica_stewart@baylor.edu, and **Lance Littlejohn**. *Spectral Analysis of the X_1 -Laguerre Polynomials*. Preliminary report.

In a series of papers which began in 2009, Kamran, Milson and Gómez-Ullate posed the following Bochner-type problem: to find all sequences of polynomials $\{p_n\}_{n=1}^\infty$, with $\deg(p_n) = n$, which are solutions of a second order differential equation of the form

$$\ell[y](x) = a_2(x)y''(x) + a_1(x)y'(x) + a_0(x)y(x);$$

are orthogonal with respect to a positive weight function $w(x)$ on a real interval; and all have moments $\{\mu_n\}$ of $w(x)$ exist and are finite.

Up to a complex change of variables, their classification result shows that the only two such sequences are the “exceptional” polynomial sequences, X_1 -Laguerre and the X_1 -Jacobi. In this lecture, which is joint work with Dr. Lance Littlejohn (Baylor), we review this classification result and specifically discuss the spectral theory and related results, for the X_1 -Laguerre polynomials. (Received September 25, 2012)

1086-VK-2816 **Caleb Andrew Meier*** (c1meier@math.ucsd.edu) and **Michael Holst**. *Non-uniqueness of Solutions to the Conformal Formulation of the Einstein Constraint Equations*.

In this talk we investigate the uniqueness properties of solutions to the Einstein constraint equations on a closed manifold. In particular, we investigate whether or not solutions to the conformal formulation of the constraints with an unscaled data source are unique. For positive, constant scalar curvature and constant mean curvature, we first demonstrate the existence of a critical energy density for the Hamiltonian constraint. We then show that for this choice of energy density, the linearization of the elliptic system develops a one-dimensional kernel in both the constant mean curvature and non-constant mean curvature cases. Using a Liapunov-Schmidt reduction and standard techniques from bifurcation theory, we demonstrate that solutions to the conformal formulation with unscaled data source are non-unique by determining an explicit solution curve and analyzing its behavior in the neighborhood of a particular solution. (Received September 25, 2012)

General Session on Research in Applied Mathematics

1086-VL-293 **Xinyao Yang*** (xywp8@mail.missouri.edu), 701 S Providence Road, Apt 1I, Columbia, MO 65203. *Stability estimates for semigroups on Banach space.*

In this presentation, I will examine how partial differential equations can be supplemented by phase conditions that can help researchers to compute nonlinear waves as regular zeros of the resulting nonlinear system. (Received August 16, 2012)

1086-VL-346 **Ramesh Yapalparvi*** (ramesh.yapalparvi@gmail.com), 2525 Pottsdamer St, Tallahassee, FL 32310, and **Bartosz Protas**. *Computation of Effective Free Surfaces in Two Phase Flows*. Preliminary report.

In this investigation we revisit the concept of “effective free surfaces” arising in the solution of the time-averaged fluid dynamics equations in the presence of free boundaries. This work is motivated by applications of the optimization and optimal control theory to problems involving free surfaces, where the time-dependent formulations lead to many technical difficulties which are however alleviated when steady governing equations are used instead. By introducing a number of precisely stated assumptions, we develop and validate an approach in which the interface between the different phases, understood in the time-averaged sense, is sharp. In the proposed formulation the terms representing the fluctuations of the free boundaries and of the hydrodynamic quantities appear as boundary conditions on the effective surface and require suitable closure models. As a simple model problem we consider impingement of free-falling droplets onto a fluid in a pool with a free surface, and a simple algebraic closure model is proposed for this system. The resulting averaged equations are of the free-boundary type and an efficient computational approach based on shape optimization formulation is developed for their solution. (Received August 23, 2012)

1086-VL-536 **Jean-Paul Berrut*** (jean-paul.berrut@unifr.ch), University of Fribourg, Department of Mathematics, Perolles, CH-1700 Fribourg, Switzerland. *Boole’s summation formula and features of jump singularities*. Preliminary report.

The Euler-Maclaurin formula writes the sum $T(h)$ of equispaced values of a function on the circle as an integral plus the difference, consisting of the sum of a polynomial in the interval mesh h and another integral multiplied by a larger power of h . It was originally employed by Euler to approximate such sums of function values by integrals, before Romberg used it the other way around, namely to approximate integrals by extrapolating sums $T(h)$ for decreasing h .

As mentioned several times in recent years by J. Borwein and collaborators, a much less well known formula is that by Boole, which gives a corresponding expression for the *alternating* sum $A(h)$. Boole obtained it through the study of finite differences. In most appearances in print, only the idea of the proof is given; we first derive it here from the Euler-Maclaurin formula. Then, in the wake of Romberg, we use it to estimate one-sided limits of functions at jumps by extrapolating values $A(h)$ for decreasing h . (Received September 06, 2012)

1086-VL-588 **Ramanjit K Sahi*** (sahir@apsu.edu), **Samuel Jator** and **Noureen Khan**. *Direct numerical approach for solving Falkner-Scan Equations*.

Many applications in engineering are modeled by third order boundary value problems such as Falkner-Scan, Blasius and Sandwich beam problems. Generally, most of the problems are solved by first reducing them to an equivalent system of first order differential equations. In this presentation, we apply a fourth order method to solve Falkner-Scan equations directly, thereby saving computer time. We perform numerical experiments to show efficiency and accuracy advantages of the new method over existing ones in literature. (Received September 07, 2012)

1086-VL-759 **Myung-Sin Song*** (msong@siue.edu), Department of Mathematics and Statistics, Southern Illinois University Edwardsville, Edwardsville, IL 62026. *Haar Wavelet-like Analysis with MRA Method Extended to Fractals*.

Extending the Haar wavelet-like analysis with MRA method to both fractals and to discrete hierarchical models to study two computational features: (a) Approximation of the father or mother functions by subdivision schemes, and (b) matrix formulas for the wavelet coefficients where a variety of data will be considered; typically for fractals, convergence is more restrictive than is the case for wavelets. This makes wavelets closely related to fractals and fractal processes. Investigation of the relation between wavelets and fractals and fractal processes has theoretical and practical potential. It has been recently shown (by Palle Jorgensen, Ola Bratteli, David Larson, X. Dai and others) that a unifying approach to wavelets, dynamical systems, iterated function systems, self-similarity and fractals may be based on the systematic use of operator analysis and representation theory.

Motivated by hierarchical models and multiscaling, operators of multiplication, and dilations, and more general weighted composition operators are studied. In these models, scaling is implemented by non-linear and non-invertible transformations. This in turn generalizes affine transformations of variables from wavelet analysis and analysis on affine fractals. (Received September 12, 2012)

1086-VL-788 **Qingxia Li** (liq@lincolnu.edu), 701 S Providence Road, Apt 11, Columbia, MO 65203, and **James Schrader*** (jamesschrader22@yahoo.com), 804 Hwy D, Osage Beach, MO 65065. *Nonlinear Linear Programming for Multivalued Mappings.*

In this presentation, we will construct a concrete example to demonstrate the conjugate duality theory in vector optimization. We will also denote the corresponding normal cones from the concept of the subgradients and tackle some convolution properties for convex set valued mappings. (Received September 12, 2012)

1086-VL-957 **Eric Alan Eager*** (eeager@uwlax.edu), 1725 State St., La Crosse, WI 54601. *Global Asymptotic Stability of Density-Dependent Age-Structured Plant-Seed Bank Models.*

Many plant populations have persistent seed banks. Seed banks are important for plant population dynamics because they buffer against environmental perturbations and reduce the probability of extinction. Viability of the seeds in the seed bank can depend on the seed's age, hence it is important to keep track of the age distribution of seeds in the seed bank. In this talk we introduce a general, density-dependent plant-seed bank model where the seed bank is age-structured and the plant population lives in a general Banach Space. Under biologically reasonable assumptions we prove that there is a globally stable equilibrium population vector which is independent of initial population vector. We show that there is an analytical formula for the equilibrium using methods from systems and control theory. We apply these results to a published model for *Sesbania vesicaria*. (Received September 17, 2012)

1086-VL-1139 **Leon Kaganovskiy*** (leonkag@gmail.com), 1233 E 19th St Apt 6J, Brooklyn, NY 112305474, and **Robert Krasny** (krasny@umich.edu), 525 Church Street, Ann Arbor, MI 48106-0606. *Numerical Simulation of Vortex Ring Instability and Collisions.*

Vortex sheet model and Lagrangian particle/panel method is employed to represent vortex sheet surface in 3D incompressible. The particles representing the sheet are advected by a regularized Biot-Savart integral with smoothed Rosenhead-Moore kernel. The particle velocities are evaluated by an adaptive hierarchical treecode algorithm based on Taylor expansions in Cartesian coordinates. Intricate details of instabilities and late stages of rings collisions could be illuminated with this method. Vortex sheet approach allows us to see the details of ring's roll-up, vorticity iso-surfaces, and axial flow observed in experiments. (Received September 19, 2012)

1086-VL-1246 **Ellen R. Swanson*** (ellen.swanson@centre.edu). *Comparison between two models for spreading on a thin liquid film.*

Surfactant lowers the surface tension of a fluid, which drives the fluid from the area of lower surface tension to an area of higher surface tension. One application for surfactant is a medical treatment for premature babies called Surfactant Replacement Therapy. The interest in a model of a monolayer of surfactant on a thin liquid film was sparked by this treatment. The model consists of two nonlinear fourth order partial differential equations. One equation models the height of the film while the other models the surfactant concentration. However, in many instances more than a monolayer of surfactant is present. In this case, the surfactant is modeled as a droplet of fluid on the film. This model is also a fourth order nonlinear system of partial differential equations. In this case, the system consists of three equations. We will discuss the similarities and differences in the models for a monolayer of surfactant and a droplet on a thin liquid film. (Received September 20, 2012)

1086-VL-1467 **Andrzej K Brodzik*** (vespertilionoidea@yahoo.com). *Design of polyphase sequences with sparse disjoint support discrete Fourier transform.*

In this work the design of polyphase sequence sets with sparse disjoint support semi-polyphase discrete Fourier transform is considered. The design is undertaken in the generalized Fourier space, the Zak space. Several tessellations and tessellation combinations of the Zak transform lattice, including the tessellation $KM^2 \times M$, where $KM \in \mathbb{Z}$, are analyzed. Sequence constructions associated with these tessellations are characterized in terms of sparsity of the discrete Fourier transform, flexibility of spectral null placement, correlation properties, sequence set size, and multiplicity of constructions. (Received September 26, 2012)

- 1086-VL-1480 **Catherine Mareva Kublik*** (catkublik@gmail.com), **Nicolay M Tanushev** and **Richard Tsai**. *An Implicit Interface Boundary Integral Method for Poisson's Equation on Arbitrary Domains*.

We propose a simple formulation for constructing boundary integral methods to solve Poisson's equation on domains with piecewise smooth boundaries defined through their signed distance function. Our formulation is based on averaging a family of parameterizations of an integral equation defined on the boundary of the domain, where the integrations are carried out in the level set framework using an appropriate Jacobian. By the coarea formula, the algorithm operates in the Euclidean space and does not require any explicit parameterization of the boundaries. We present numerical results in two and three dimensions. (Received September 22, 2012)

- 1086-VL-1507 **Shawn Michael Westmoreland*** (westmore@math.ksu.edu), 2020 Tunstall Circle, Apt. 11, Manhattan, KS 66502. *Optical black holes and solitons*.

As Novello has emphasized, light rays in nonlinear electrodynamics follow null geodesics with respect to an effective geometry which generally differs from the background gravitational spacetime geometry. A form of nonlinear electrodynamics which is a good approximation to quantum electrodynamics is Euler-Heisenberg (EH) theory. The question can be raised whether it is possible for (optical) black holes to form in the EH effective geometry. Indeed, we already have an exact solution to the EH field equations for which the corresponding effective geometry contains a cylindrical black hole. It is conjectured that there are also soliton solutions to the EH field equations corresponding to black holes. (Received September 22, 2012)

- 1086-VL-1610 **Jacquelyn L. Rische*** (jrische@math.uci.edu). *Mathematical Modeling of Language*. Preliminary report.

We consider a population without language on a two-dimensional grid. Through mutation, individuals with language appear. Using mathematical models, we study how the individuals with language spread through the population. One aspect we focus on is the effect of talking. If two individuals with language are next to each other on the grid, then they can communicate. We consider their ability to talk to be advantages, giving them a higher reproduction rate. We also consider the effects of movement, where individuals are able to move around on the grid. (Received September 23, 2012)

- 1086-VL-1719 **Sarah Miracle**, **Dana Randall** and **Amanda Pascoe Streib*** (amanda.streib@nist.gov). *Clustering in interfering models of binary mixtures*.

Colloids are binary mixtures of molecules with one type of molecule suspended in another. It is believed that at low density typical configurations will be well-mixed throughout, while at high density they will separate into clusters. We characterize the high and low density phases for a general family of discrete *interfering binary mixtures* by showing that they exhibit a "clustering property" at high density and not at low density. The clustering property states that there will be a region that has very high area, very small perimeter, and high density of one type of molecule. To demonstrate the existence of the clustering property at high density, for example, we use careful combinatorial arguments to show that the vast majority of configurations have the clustering property, so that with high probability, a random configuration will as well. (Received September 24, 2012)

- 1086-VL-1733 **Seth D. Haney*** (shaney@sandiego.edu), shaney@sandiego.edu, and **Matthew Cattivera** and **Adam Siepielski**. *Mean Exit Time as a Metric of Ecological Stability in Stochastic Lotka-Volterra Models*. Preliminary report.

Stochastic effects can fundamentally change the outcome of systems in competition. Here we use a discrete and probabilistic model for two competing species to numerically calculate mean exit time, which is analogous to the length of time until one species becomes extinct. Using extinction time as a metric, we evaluate the effectiveness of a spectrum of well-known mechanisms of coexistence, which rely on strict ecological distinctiveness (niche theory) and strict ecological equivalence (neutral theory). We also propose a novel method for potential coexistence of equivalent competitor species. We compare the results of our probabilistic discrete model to a probabilistic continuous Fokker-Planck Equation (FPE). We show that, in certain situations, extinction is a fundamentally discrete phenomenon. In particular we look at systems with absorbing boundaries that are deterministically unstable, and eventually the discrete probabilistic models invariably reside at the absorbing boundary (with probability 1). In contrast, we show that the FPE models invariably avoid these deterministically unstable absorbing boundaries. (Received September 24, 2012)

- 1086-VL-1786 **Matt Zumbrum*** (zumbrum@math.udel.edu). *Surface-Volume Reactions and Optical Biosensors with Arrays of Reacting Zones*. Preliminary report.

Surface-volume reactions occur in many biological and chemical processes. In a surface-volume reaction, one reactant is contained in a fluid which flows over a surface to which another reactant is immobilized. Unlike the case where reactants are well-mixed, standard kinetics cannot be applied to these reactions and transport effects must be taken into account.

Optical biosensors are devices widely used to replicate surface-volume reactions and to measure reaction rate constants. Early biosensors included a single reacting zone for the study of a single reaction. New devices include arrays of reacting zones in a single flow channel, allowing for the study of up to four hundred reactions simultaneously. Real time measurements of bound reactants in a reacting zone are taken and averaged to obtain a sensogram of the bound state.

We consider the reaction-limited problem with small Damköhler number and discuss a model for ligand depletion and bound state evolution over arrays of reacting zones using perturbation analysis. We extend previous work to arrays of reacting zones with different association and dissociation rates, including an effective rate constant (ERC) equation for individual reacting zones. (Received September 24, 2012)

- 1086-VL-1922 **J. Pascal*** (pascal_jesus@yahoo.com). *A Viscosity Solution of the Dynamic Programming Equation for an Optimal Control Problem*. Preliminary report.

The issue addressed in this paper refers to the class of infinite horizon stochastic optimal control problems. A one dimensional stochastic optimal control problem is considered and differential equations methods are used to piece together a viscosity solution of the dynamic programming equation for this control problem. (Received September 24, 2012)

- 1086-VL-1923 **Heather Rosenblatt*** (rosenblatt@math.ohio-state.edu), Department of Mathematics, The Ohio State University, 231 West 18th Ave, Columbus, OH 43210, and **Xing Liu, Hyejin Park** and **Saleh Tanveer** (tanveer@math.ohio-state.edu), Department of Mathematics, The Ohio State University, 231 West 18th Ave, Columbus, OH 43210. *Rigorous Computation of Stokes Constant in problems with parameters*.

We introduce a mathematically rigorous method of calculating Stokes constant in a nonlinear problem containing parameters. In particular, we show how such computations help in a rigorous theory for selection of finger width in steady viscous fingering. (Received September 24, 2012)

- 1086-VL-2104 **Yanling Liu*** (yliu2@math.fsu.edu), Department of Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306, and **M. Yousuff Hussaini** and **Giray Okten**. *Optimization of a Monte Carlo Variance Reduction Method Based on Sensitivity Derivatives*.

We propose an optimization technique for an efficient sampling method known as sensitivity derivative enhanced sampling (SDES). It has been shown in certain cases that SDES can bring no improvement over or even slow crude Monte Carlo sampling. Our proposed optimized version of SDES guarantees variance reduction and improved accuracy in estimates. The optimized SDES can also improve randomized quasi-Monte Carlo (RQMC) sampling, which converges with a higher rate compared to the Monte Carlo sampling. Numerical experiments are performed on three test cases including generalized steady-state Burgers equation and Korteweg-de Vries equation. The results show that the optimized SDES can improve crude Monte Carlo (or RQMC) and SDES by up to an order of magnitude. RQMC coupled with the optimized SDES provides the largest efficiency gains, which can be as high as 1800. (Received September 24, 2012)

- 1086-VL-2196 **Alexandra V Pasi*** (avp0826@westminstercollege.edu) and **Richard Wellman**. *Differential Equations for the Construction of Novel Kernels in Machine Learning*.

Significant research in Machine Learning has been directed at the application and implementation of kernel-based learning methods. However, few studies have focused on the problem of kernel construction. This paper introduces a novel method for generating new kernels by solving differential equations for kernel functions. We examine specific kernels generated using this method. These kernels are applied to various data sets and compared against state-of-the-art kernels. (Received September 25, 2012)

- 1086-VL-2197 **Joseph Roberts*** (joeprob@umich.edu) and **Volker Elling**. *Small Steady Self-Similar Inviscid Flows*.

We consider solutions of the two dimensional compressible Euler equations that are steady (no time dependence) and self-similar (constant along rays emanating from a distinguished point). Examples arise naturally at interaction points in genuinely multi-dimensional flow (for example, regular reflection or Mach reflection). We are

able to classify all possible solutions that are L^∞ -close to a constant supersonic background, and show that they are in fact of bounded variation. As a special case we obtain that self-similar (in this case, depending only on $\frac{x}{t}$) solutions of 1-d Riemann problems are of bounded variation, and the forward in time solutions are unique in the class of small L^∞ perturbations of a constant solution. We obtain a similar classification for any strictly hyperbolic system (that is, a system with simple eigenvalues) of conservation laws endowed with a convex entropy. (Received September 25, 2012)

- 1086-VL-2201 **Aleksey S. Telyakovskiy*** (alekseyt@unr.edu), Department of Mathematics and Statistics, University of Nevada, Reno, NV 89557, and **Jeffrey S. Olsen**, Graduate Problem of Hydrologic Sciences, University of Nevada, Reno, NV 89557. *Construction of approximate analytical solution to the porous medium equation.*

The porous medium equation appears in multiple applications, for example in hydrology it is known as a generalized Boussinesq equation. It can model filtration of polytropic gases through the porous medium, as well as movement of liquid in aquifers. We consider a zero initial condition, i.e. no substance is present at first, and the case of the special boundary conditions. Using dimensional analysis we can transform problem for the partial differential equation to a boundary value problem for a nonlinear ordinary differential equation. We construct polynomial in nature expression for the scaling function in terms of the similarity variable. (Received September 25, 2012)

- 1086-VL-2335 **Sridevi Pudipeddi*** (sridevi.pudipeddi@normandale.edu), 9700 France Ave S, Bloomington, MN 55431, **Ravishankar Chityala** (chityala@msi.umn.edu), 560 Walter Library, 117 Pleasant Street SE, Minneapolis, MN 55455, and **Robert Jones** (rsjones@umn.edu), 6-150 Moos Health Science Tower, 515 Delaware Street S.E., Minneapolis, MN 55455. *Reconstruction of Optical Coherence Tomography Images using Inpainting.* Preliminary report.

In Optical coherence tomography (OCT) imaging, disposable poly vinyl coverings and total internal reflections cause artifacts. These artifact can be removed using image inpainting, a process of filling the damaged portion of an image.

In OCT, speckle patterns are observed in the image. The speckle patterns are random and hence two different regions will have different speckle pattern. The exemplar based inpainting performs an exhaustive search since it requires that the mask and region under artifact to be similar. Hence the method is computationally expensive and time consuming.

In the proposed method, we aim to remove the artifacts in two steps using an algorithm tailored specifically for OCT. In the first step, we will study the speckle pattern close to the artifact and characterize its distribution. In the second step, we will use the estimated Gaussian distribution to remove the artifact. (Received September 25, 2012)

- 1086-VL-2356 **Eugene S. Li*** (eugene.li@montgomerycollege.edu), 51 Mannakee St., Dept. of Physics, Engineering and Geoscience, Montgomery College, Rockville, MD 20850, and **Gerald Katzin** (katzin@mindspring.com), Dept. of Physics, NC State University, 2401 Stinson Drive, Box 8202, Raleigh, NC 27695. *Applying the Role of Differential Identities as an Efficient Tool for Understanding Symmetries and Conservation Laws in Dynamical Systems.* Preliminary report.

The role of differential identities in analyzing the connection between local point-transformations on the infinite jet prolongation of the configuration bundle for a dynamical system and its dynamical symmetries and conservation laws will be presented. In particular, it is noted that differential identities expressed as partial differential equations are generalized forms of Green's Vector Identity, and can be used as such, as an analytical tool to establish connections between symmetries, and conservation laws. The efficiency of the method as applied to Noether's Theorem, as to formulating the relationship between symmetries and conservation laws, will be demonstrated. (Received September 26, 2012)

- 1086-VL-2405 **Adrianna M Gillman*** (adrianna.gillman@dartmouth.edu), Department of Mathematics, 6188 Kemeny Hall, Hanover, NH 03755. *Fast direct solvers for elliptic boundary value problems.*

Often elliptic boundary value problems can be reformulated as integral equations. Upon discretization, one is left with the task of solving a large dense linear system that can be solved via an iterative solver (e.g GMRES) coupled with a fast matrix vector multiplication scheme such as the fast multipole method (FMM). Unfortunately, when the system is ill-conditioned (as often happens for complicated geometries) the method can take hundreds of iterations to converge. Additionally iterative methods are not able to efficiently solve problems with multiple

right hand sides that frequently arise in design applications. In contrast, the methods we present in this talk are “direct” in the sense that they construct an approximation to the inverse of the matrix. Such direct solvers tend to be more robust, versatile, and stable than iterative methods. This talk will demonstrate that in important environments it is possible to construct an approximate inverse with a computational cost that scales linearly with the number of discretization points. Once constructed, the approximate inverse can be applied with linear computational cost, making direct solvers ideal in situations where the same coefficient matrix is used in sequence of problems. (Received September 25, 2012)

- 1086-VL-2432 **Ahad Dehghani*** (ahad.dehghani@gmail.com), 1001 Sherbrooke West, Montreal, Quebec H3A 1G5, Canada, **Jean-Louis Goffin** (jean-louis.goffin@mcgill.ca), 1001 Sherbrooke West, Montreal, Quebec H3A 1G5, Canada, and **Dominique Orban** (dominique.orban@gerad.ca), HEC Montréal 3000, chemin de la Côte-Sainte-Catherine, Montreal, H3T 2A7, Canada. *A Primal-Dual Regularization Interior-Point Method for Semidefinite Programming.*

Interior-point methods in semidefinite programming (SDP) require the solution of a sequence of linear systems which are used to derive the search directions. Safeguards are typically required in order to handle rank-deficient Jacobians and free variables. We propose a primal-dual regularization to the original SDP and show that it is possible to recover an optimal solution of the original SDP via inaccurate solves of a sequence of regularized SDPs for both the NT and dual HKM directions. (Received September 25, 2012)

- 1086-VL-2539 **Rodrigo B. Platte** and **Alexander J. Gutierrez*** (ajg@asu.edu), 527 E Hermosa Dr., Tempe, AZ 85282, and **Anne Gelb**. *Edge informed Fourier reconstruction from non-uniform spectral data.*

Reconstruction of piecewise smooth functions from non-uniform Fourier data arises in sensing applications such as magnetic resonance imaging (MRI). This paper presents a new method that uses edge information to recover the Fourier transform of a piecewise smooth function from data that is sparsely sampled at high frequencies. The approximation is based on a combination of polynomials multiplied by complex exponentials. We obtain super-algebraic convergence rates for a large class of functions with one jump discontinuity, and exponential convergence for piecewise analytic functions of compact support. By casting the approximation problem in optimization form, our method can also improve initial jump location estimates, which are calculated from the available Fourier data. Finally, if the Fourier transform is approximated at integer values, then the IFFT can be used to reconstruct the underlying function. Post-processing techniques, such as spectral reprojection, can then be used to reduce Gibbs oscillations. (Received September 25, 2012)

- 1086-VL-2679 **Adam M Fox*** (adam.fox@colorado.edu). *Greene’s Criterion for the Breakup of Invariant Tori of Volume Preserving Maps.*

Invariant tori play a prominent role in the dynamics of symplectic maps. These tori are especially important in two dimensional systems where they form a boundary to transport. Volume preserving maps also admit families of invariant rotational tori, which will restrict transport in a d dimensional map with one action and $d-1$ angles. These maps most commonly arise in the study of incompressible fluid flows, however can also be used to model magnetic field-line flows, granular mixing, and the perturbed motion of comets in near-parabolic orbits. Although a wealth of theory has been developed describing tori in symplectic maps, little of this theory extends to the volume preserving case. In this talk we will explore the invariant tori of a 3 dimensional quadratic, volume preserving map with one action and two angles. A method will be presented for determining when an invariant torus with a given frequency is destroyed under perturbation, based on the stability of approximating periodic orbits. (Received September 25, 2012)

- 1086-VL-2718 **Andrew J Knapp*** (andrew.knapp@asu.edu). *WENO Simulations of Astrophysical Jets.* Preliminary report.

Galactic nuclear jets are known to trigger star formation when colliding with interstellar gas. However, the effects of protostellar jets on star formation are not known. Current observations of protostellar jets propagating through nebulae are not yet detailed enough to determine if gravitationally bound objects are formed, motivating numerical investigation. In this talk, we will discuss the application and parallel implementation of Weighted Essentially Non-Oscillatory (WENO) finite volume schemes to collisions between protostellar jets and nebulae, and present the results of our numerical experimentation.

(Received September 25, 2012)

- 1086-VL-2743 **Robert Simpson Baker*** (zanotam@gmail.com), 718 W Muirwood Dr., Phoenix, AZ 85045. *Fitting and Analysis of the Distribution Function of Relaxation Times for the Polarization Estimation Inverse Problem for Solid Oxide Fuel Cells.*

The mathematical goal of our analysis of the problem was to produce a set of curves which when superimposed fit a set of calculated results and calculate the curves local maxima, or ‘centers’, and area under the curves. To do so we had to determine a family of potential curves, bounds for the number of curves, and methods to fit the superposition of the curves. Based upon inspection of approximate data and some theoretical concerns we examined probability distributions, deciding on a weighted log-normal probability distribution function. After some visual examination, we determined that the number of curves was two, three, or four, most likely three, with more real data being required to confirm the exact number. We then needed to use a non-linear least squares fitting method, with several algorithms and slight variations of the main algorithms considered. The calculations then of the integral of the log-normal PDF’s and the center were possible, but specifics of the methods used to preprocess the data for the nonlinear least squares fitting, including potential normalization, and the set-up and numerical aspects of the fitting itself complicate the usefulness of those final calculations. (Received September 25, 2012)

- 1086-VL-2776 **Holly Timme*** (htimme@vt.edu), Virginia Tech, Department of Mathematics, 460 McBryde Hall, Blacksburg, VA 24061. *Modeling the curvature of a fluid interface using the height function method.* Preliminary report.

Fluid interface properties are typically computed numerically within the framework of a PDE solution method. Volume of Fluid (VOF) is a simple finite-difference based method that exhibits excellent volume-conserving properties of the fluid. Within this framework, however, differential properties such as the normal and curvature of the interface are poorly computed. Recently, the use of a local integral property, or “height function,” has been shown to allow more accurate curvature computation within VOF for some interface configurations. The height function (HF) method is a technique for estimating interface normals and curvatures from well-resolved volume fraction data that shows second-order convergence with grid refinement. In this presentation, we use HF to approximate the geometrical properties of an elliptical interface and analyze the errors that result for arbitrary curvatures and orientations with respect to a wide range of grids. We demonstrate that HF’s best results occur when the interface curvature is weak and its orientation aligns with one of the underlying computational grid directions. Finally, we examine the impact of the height function method in two-dimensional simulations of ferrofluids in an imposed uniform magnetic field. (Received September 25, 2012)

- 1086-VL-2880 **Casey D. McGrath*** (casey_mcgrath@redlands.edu) and **Joanna Bieri** (joanna_bieri@redlands.edu). *Characteristics of Non-Symmetric Edge Flames in Micro-Channels.* Preliminary report.

The characteristics and dynamics of non-symmetric edge flames created from the unequal supply of fuel and oxidizer are studied in the confined channel of a micro-combustor. Upon entering the fuel and oxidizer are separate, but after flowing past a splitter plate that divides the channel initially they are free to mix and ignite. The resulting flame has a tribrachial structure with a curved premixed leading edge and a diffusion flame tail. The structure and position of the flame can change dramatically, which is often caused when the stoichiometry of the reactants is unbalanced. Thus far, the research has indicated extinction points for these non-symmetric edge flames and has given a better understanding of how size and shape are affected by different mixture ratios – under fuel rich and fuel lean conditions. Stability is also affected, and many times non-symmetric flames will have a specific range of flow speeds at which the flame can be sustained and at which it will be unstable. Instability ranges from blow-off, where the flame will completely extinguish, to oscillations around a point through time. Future work will continue the stability analysis, as well as include a more in-depth investigation of the reaction strength of certain flames and the effect of heat losses. (Received September 25, 2012)

- 1086-VL-2895 **Csilla Szabo*** (csilla.szabo@usma.edu). *Resource Networks’ Influence on the Social Network and the Effectiveness of Public Policy.* Preliminary report.

Water and energy sustainability continues to be a challenge faced across the world. With continued urbanization and changes in the Earth’s climate, these challenges will likely multiply in the decades to come. The resource networks of energy and water are directly linked and vital to the success of a country. This success is not limited to economic advancements, but also the well being of its people as measured by the social issues associated with education, technology, and health care, to name just a few. Public policy enacted by local and national governments drives many of these developments, but non-governmental organizations (NGOs) and behaviors of individuals and communities also play a crucial role in resource utilization and distribution. The complexity of this network is a challenge for governments of developing nations. Here we model the existing flow networks

of energy and water in a developing country along with the social and government networks that influence and enact public policy and map the dynamics of the social, political and economic networks to measure the extent to which they react or adapt to new technologies and renewable energy. (Received September 26, 2012)

1086-VL-2950 **Assane Gueye*** (assane.gueye@gmail.com). *A Game Theoretic Approach to Communication Security*. Preliminary report.

We consider the security/availability problem and model it as a 2-player quasizero-sum game. We use the theory of blocking pairs of polyhedra (BPP) to characterize and analyze the Nash equilibria of the game. We illustrate the study by considering the particular problem of security/availability of communication networks. Using the theory of blocking pairs of polyhedra to analyze communication network security games has permitted us to 1) describe the worst-case attack on a communication network, 2) derive a closed-form characterization of the most critical links of the network, and 3) derive meaningful metrics for communication network vulnerability. All our game theory based metrics can be related to metrics derived from a purely graph theory analysis. (Received September 26, 2012)

1086-VL-2983 **Du Pham*** (dpham@butler.edu), 4600 Sunset Ave., Indianapolis, IN 46208. *On the stability and convergence results of finite volume schemes for diffusion problems with a gradient-dependent diffusion coefficient*. Preliminary report.

We discretize a nonlinear diffusive equation by finite difference in space and by finite volume in time. We then prove a weighted Poincaré inequality to show a stability result of the scheme. We finally discuss convergence result of the scheme with a compactness result due to its nonlinearity. (Received September 26, 2012)

General Session on Research in Geometry and Linear Algebra

1086-VM-379 **Steven Waruhiu*** (waruhius@uchicago.edu). *Surface-area-minimizing n -hedral tiles*. Preliminary report.

For fixed n , we seek an n -hedral tile of space of unit volume and least surface area. We provide a conjecture which lists our candidates from a certain irregular tetrahedron ($n = 4$) to Kelvin's truncated octahedron ($n \geq 14$). We provide proofs of the conjecture for $n = 5, 4$. That a right equilateral-triangular prism is the best 5-hedral tile was known. However, there is only one published proof, which Florian calls "very troublesome" by Sucksdorff in 1857. We provide what we think is a nicer proof. The proof of the best orientation-preserving tetrahedral tile follows from a classification of tetrahedral tiles by Sommerville. (Received August 27, 2012)

1086-VM-487 **Judith A. Silver*** (silver@marshall.edu), Department of Mathematics, Marshall University, One John Marshall Drive, Huntington, WV 25701, and **Anna Mummert**, **Donald W. Silver** and **Leah Treadaway Billo**. *Conics on a Sphere*.

In this presentation we investigate conics (ellipses, parabolas, and hyperbolas) on a sphere, by extending the projective geometry definition for conics on a plane. In projective geometry, a two-dimensional planar conic can be defined as the locus of intersection points of two pencils of lines. A pencil of lines is the set all lines through a given point. We describe two different methods to generate planar conics using pencils of lines, one method easily generates circles and transformations of $y = 1/x$, and the other easily generates ellipses and other hyperbolas. The two generation methods are extended to the spherical case. Conics on a sphere are defined as the locus of intersection points of two pencils of great circles. We provide a *Mathematica* program to visualize conics on a sphere. In the spherical case, there is no clear graphical distinction between ellipses, parabolas, and hyperbolas; they can, however, be distinguished by analyzing the generating lines. (Received September 21, 2012)

1086-VM-528 **Julianne Teng*** (julianneteng17@yahoo.com). *Angle constructability on lattices generated by different quadrilaterals*.

We begin by defining a "constructible angle." Then, we discuss how to prove two lattices have the same constructible angles. Finally, we use the above definition and process to prove certain lattices have the same angle constructibility: including square lattices, certain trapezoidal lattices, and certain parallelogram lattices. (Received September 05, 2012)

- 1086-VM-567 **Michael Woltermann*** (mwoltermann@washjeff.edu), Washington and Jefferson College, Mathematics Department, 60 S. Lincoln St., Washington, PA 15301-4801. *Fregier Families of Conics*.

Fregier's Theorem states that if from a point P on a conic any two perpendicular lines are drawn cutting the conic in points Q and R , then line QR meets the normal at P at a fixed point P' . This talk presents a traditional older proof of the theorem and looks at the locus of P' , and what happens when this process is iterated both forwards and backwards. (Received September 07, 2012)

- 1086-VM-657 **Andrew J. Klimas*** (aklimas@xula.edu), Xavier University of Louisiana, Department of Mathematics, New Orleans, LA 70125. *Extremals and Faces of the Completely Positive and Positive Semidefinite-Preserving Cones*.

This paper on the extremals and faces of the cone $\pi(PSD_n)$ of positive semidefinite-preserving linear transformations on the complex vector space of complex matrices of order n and its self-dual subcone CP_n of the completely positive linear transformations expands on previous work to say more about the extremals of $\pi(PSD_n)$, namely that every nonsingular element of $\pi(PSD_n)$ is an extremal of $\pi(PSD_n)$ and every extremal of CP_n and of $coCP_n$ is also an extremal of $\pi(PSD_n)$.

While it is known that CP_n is a subcone but not a face of $\pi(PSD_n)$, whether every proper face of CP_n (in the sense of a proper subset) is a face of $\pi(PSD_n)$ is an open question. Examples of such faces do exist, but using a certain characterization of the faces of CP_n , we can exhibit a face of CP_2 that is not a face of $\pi(PSD_2)$.

Open questions remain about whether such a face can be found for $n > 2$ and whether a face of CP_n which lies in the boundary of $\pi(PSD_n)$ is necessarily also a face of $\pi(PSD_n)$. (Received September 10, 2012)

- 1086-VM-827 **Alan Durfee*** (adurfee@mtholyoke.edu), adurfee@mtholyoke.edu. *Polyhedral differential geometry*. Preliminary report.

I will give a quick survey of some elementary results in polyhedral differential geometry, including some lesser known ones, and also some questions which appear to have not been addressed.

The advantages of this approach to differential geometry are clear: The usual course in differential geometry uses smooth curves and surfaces. The prerequisites for a course like this are linear algebra and several semesters of calculus. Concepts may be subtle, proofs may be involved, and computations may take work. The main results, the Theorem Egregium and the Gauss-Bonnet theorem, have substantial proofs.

The analogous concepts in polyhedral differential geometry are easier to understand and easier to use. The prerequisites for a course in this subject are minimal. The proofs of the Theorem Egregium and the Gauss-Bonnet theorem are straightforward. In fact many of the concepts in smooth differential geometry have polyhedral analogues. Some of these results were proved long ago, others more recently.

I will describe these. (Received September 25, 2012)

- 1086-VM-834 **Yun Myung Oh*** (ohy@andrews.edu), 124 Haughey Hall, Andrews University, Berrien Springs, MI 49104. *Riemannian submersion and Lagrangian isometric immersion*.

It has been known that if a Riemannian manifold admits a non-trivial Riemannian submersion with totally geodesic fibers, then it cannot be isometrically immersed in any Riemannian manifold of non-positive sectional curvature as a minimal submanifold. B. Y. Chen proved this using an inequality involving the submersion invariant and his inequality shows the maximum value of the invariant. The author could find another inequality that gives the minimum of the submersion invariant under a certain assumption. (Received September 13, 2012)

- 1086-VM-988 **Thomas M McKenzie*** (mckenzie@gonzaga.edu). *Uniformly Distributed Sequences*. Preliminary report.

We begin by expressing many well-known results on second ordered linear recurrences over \mathbf{Z}_p in terms of matrices, eigenvectors, and eigenvalues. Then we show that such sequences are uniformly distributed if and only if the eigenvectors form a G -module. We then use this result to study uniformly distributed sequences over finite rings. (Received September 17, 2012)

- 1086-VM-1587 **S. Eastman*** (sean.eastman@armstrong.edu), 11935 Abercorn ext., Department of Mathematics, Armstrong Atlantic State University, Savannah, GA 31419. *The probability of choosing a valid correlation matrix*. Preliminary report.

Given a matrix $A \in Sym_n$ with 1's on the diagonal and the remaining entries chosen randomly from $(-1, 1)$, the probability that a valid correlation matrix is constructed decreases dramatically as n increases. In the 3×3 case, the subset of the unit cube consisting of valid correlation matrices can be visualized geometrically as a peculiar

shape with volume $\pi^2/2$. In this talk, we propose a formula for volumes (and thus probabilities) of correlation matrices in higher dimensions. (Received September 23, 2012)

1086-VM-1653 **Jonathan Sondow*** (jsondow@alumni.princeton.edu). *The parbelos, a parabolic analog of the arbelos.*

The *arbelos* is a classical geometric shape bounded by three pairwise tangent semicircles with diameters lying on the same line. We introduce a parabolic analog, the *parbelos*. After a review of the parabola, we use theorems of Archimedes and Lambert to demonstrate seven properties of the parbelos, drawing analogies to similar properties found in the arbelos, some of which may be new. Along the way we mention the Universal Parabolic Constant (an analog of π) and an origami fold. Our paper is to appear in the American Mathematical Monthly. (Received September 25, 2012)

1086-VM-1838 **Russell Lee Carden*** (russell.l.carden@rice.edu), 6100 Main St. - MS 134, Houston, TX 77005-1892, and **Derek J Hansen** (derekjhansen@gmail.com). *Ritz values of normal matrices and Ceva's theorem.*

We investigate the behavior of Ritz values of normal matrices. We apply Ceva's theorem, a classical geometric result, to understand the geometric relationship between pairs of Ritz values for a 3×3 normal matrix, and then analyze the implications for larger matrices. We find that, in the case of normal matrices, the geometric constraints on the placement of Ritz values allow for less freedom than in the Hermitian case. We use our results to analyze the restarted Arnoldi method with exact shifts applied to a 3×3 normal, non-Hermitian matrix. (Received September 24, 2012)

1086-VM-1899 **Hope K Snyder*** (snyderhk@jay.washjeff.edu), Department of Mathematics, Washington & Jefferson College, Washington, PA 15301, and **Roman Wong**. *Conics in Extended Taxicab Geometry.*

Conics under the taxicab metric are well known in geometry. In 2006, David Caballero generalized this metric to simulate the spread of forest fires in Europe. The extended taxicab distance d between two points $P(a, b)$ and $Q(x, y)$ is defined by $d(P, Q) = \max(|a - x|, |b - y|) - \min(|a - x|, |b - y|) + \sqrt{2} \min(|a - x|, |b - y|)$. Thus $d(P, Q)$ is computed using a diagonal line segment and either a horizontal or a vertical line segment. In this paper, we show that d is indeed a metric and we analyze the shapes of all the conics under this metric. These conics have more corners and surprises than those under the original taxicab distance. (Received September 24, 2012)

1086-VM-2220 **Michael de Villiers*** (profmd1@mweb.co.za), Private Bag X03, ASHWOOD, KZN 3605, South Africa. *From the Fermat point to a generalization and some applications.*

The paper will start with the problem of finding a point that minimizes the sum of the distances to the vertices of an acute-angled triangle, a problem originally posed by Fermat in the 1600's, and apparently first solved by the Italian mathematician and scientist Evangelista Torricelli. Ceva's theorem will be used to prove the following generalization of the Fermat-Torricelli point: "If triangles DBA, ECB and FAC are constructed outwardly (or inwardly) on the sides of any triangle ABC so that angle DAB = angle CAF, angle DBA = angle CBE and angle ECB = angle ACF, then DC, EA and FB are concurrent."

Though this generalization is not new, with the earliest proof from 1936 by W. Hoffer, the presented proof presented in this paper will be distinctly different. Of practical relevance is that this Fermat-Torricelli generalization can be used to solve a 'weighted' airport problem, for example, when the populations in the three cities are of different size. Apart from this practical application, this Fermat generalization easily proves the two other, relatively new, concurrency results as well. (Received September 25, 2012)

1086-VM-2399 **Marc Chamberland*** (chamberl@math.grinnell.edu). *Plane Geometry and Complex Numbers.*

While there is a long history of proving theorems in plane geometry with complex numbers, computer algebra systems can be used to find beautiful, new formulas that solidify this connection. As an example, consider the classical result that three distinct complex numbers a, b, c form the corners of an equilateral triangle if and only if

$$a^2 + b^2 + c^2 - ab - bc - ca = 0. \quad (1)$$

This fact is observed immediately from the equation

$$\begin{aligned} 2|a^2 + b^2 + c^2 - ab - bc - ca|^2 \\ = (|a - b|^2 - |b - c|^2)^2 + (|b - c|^2 - |c - a|^2)^2 + (|c - a|^2 - |a - b|^2)^2. \end{aligned} \quad (2)$$

This talk will showcase various formulas making connections to triangles, concyclic points, and other configurations. (Received September 25, 2012)

1086-VM-2487 **Tien Chih*** (tien.chih@umontana.edu), 118 Helena Ct., Missoula, MT 59801. *Abstract Affine Programming and Generalized Tucker Tableaux - Preliminary Report*. Preliminary report.

The traditional study of the theory and applications of the canonical primal maximization and the dual minimization affine constrained optimization problems have been well studied over the last hundred years. This traditional study has been very basis and coordinate dependent, as is natural for the applications to real world settings. A large part of this study is the discovery of very beautiful duality theory, and theorems regarding the existence of forms of optimal solutions.

It is natural then to attempt to describe this theory in as general, clean and abstract a way as possible. We want to abstract and generalize these situations to vector spaces of arbitrary dimension, over arbitrary ordered fields. We explore the theorems of classical affine programming, and generalize their statements to this abstract setting. We then discuss some possible approaches to demonstrating these generalized statements. (Received September 25, 2012)

1086-VM-2706 **Timothy C Melvin*** (tmelvin@math.wsu.edu), 1601 N Benton Ave, Carroll College, Math Dept, Helena, MT 59625. *Spectrally Arbitrary Zero-Nonzero Patterns and the Nilpotent Jacobian Method*.

A zero-nonzero pattern \mathcal{A} is a matrix whose entries are from the set $\{*, 0\}$. We say that an $n \times n$ zero-nonzero pattern is a spectrally arbitrary pattern (SAP) over the field \mathbb{F} if for every monic polynomial $p(x)$ with coefficients from \mathbb{F} of degree n , there exists a matrix A over \mathbb{F} with zero-nonzero pattern \mathcal{A} such that the characteristic polynomial of A is $p(x)$. The Nilpotent-Jacobian Method is a powerful tool used to determine if a pattern \mathcal{A} is a SAP, when the field \mathbb{F} is \mathbb{R} . We will explore what (if any) information can be gleaned from this method when we look at a pattern over other fields, including finite fields, \mathbb{Q} , $\overline{\mathbb{Q}}$ (the algebraic closure of \mathbb{Q}), and \mathbb{C} . (Received September 25, 2012)

1086-VM-2730 **Joshua Kaminsky*** (jbkaminsky@smcm.edu). *Rolling down the hill from convex hull to closure*. Preliminary report.

We investigate r -convexity of sets as a natural generalization of convexity, along with its relation to geometric minimization problems and data denoising. We also investigate how it compares to other set estimation properties. (Received September 25, 2012)

General Session on Research in Graph Theory and Combinatorics

1086-VN-531 **Max A Gross*** (maxgross17@gmail.com), 4 Isaac Ln, Cherry Hill, NJ 08002, and **Nicole Marsaglia** (nicolemarsaglia@gmail.com), 4593 Orchard Heights Rd, Salem, OR 97304. *Vexillary Permutations*.

This paper examines the permutation matrix of a vexillary permutation and its reduced expressions. The Vexillary Metropolis Algorithm is created to generate random vexillary permutations after a chosen number of simple transpositions by swapping neighboring elements and checking to ensure that the permutation remains vexillary after each swap. A swap is undone if it creates a nonvexillary subpermutation. Ultimately, reduced expressions are generated in a similar fashion as in Angel, Holroyd, Romik and Virág's paper "Random Sorting Networks," by employing the Hook Walk Algorithm and inverse Edelman-Green process. In addition to a discussion of the patterns found in the matrices of vexillary permutations, this paper includes a proof of the algorithm's ability to generate all possible vexillary permutations, a proposition that if there exists more than one nonvexillary subpermutation then the only simple transposition that can be performed is switching back the transposed elements and a proposition of the maximum number of nonvexillary subpermutations that a simple transposition can yield. (Received September 06, 2012)

1086-VN-721 **Brian G Kronenthal*** (kronenth@math.udel.edu), University of Delaware, Department of Mathematical Sciences, Ewing Hall 501, Newark, DE 19716. *On Algebraically Defined Graphs and Generalized Quadrangles*.

Let q be an integer. Consider the problem of constructing a girth eight $(q+1)$ -regular bipartite graph containing the minimum possible number of vertices. For a given odd prime power q , there is only one known solution:

the incidence graph of a *generalized quadrangle*. This graph contains a special induced subgraph denoted $\Gamma_3(q)$, which is called a *monomial graph* due to the monomials that determine its structure. Indeed, $\Gamma_3(q)$ is a bipartite graph with partite sets $P = \mathbb{F}_q^3 = L$. Vertices $(a_1, a_2, a_3) \in P$ and $[x_1, x_2, x_3] \in L$ are adjacent if and only if $a_2 + x_2 = a_1 x_1$ and $a_3 + x_3 = a_1 x_1^2$. In this talk, we will address the viability of using other algebraically defined graphs to construct additional generalized quadrangles over finite fields of odd order. In addition, we will discuss a related problem over the complex numbers. (Received September 11, 2012)

1086-VN-744 **Wiseley Wong*** (wawong@udel.edu). *Toughness of Some Graphs*. Preliminary report. The vertex-toughness of a graph is a parameter relating to connectivity. The toughness is defined as the minimum value of $\frac{|S|}{c(G \setminus S)}$, where S runs through all subsets of vertices that disconnect the graph, and $c(G \setminus S)$ denotes the number of components from removing the subset of vertices. We determine the toughness of some graphs and provide sufficient eigenvalue conditions for specific toughness values. This is joint work with Sebastian Cioabă. (Received September 16, 2012)

1086-VN-816 **Daniel P Biebighauser*** (biebigha@cord.edu), Concordia College, Moorhead, MN 56562. *Moveable Firefighters in the Firefighter Problem*. In the Firefighter Problem introduced by Hartnell in 1995, we consider strategies for defending against the spread of a fire in a graph. One of the assumptions in the original problem is that the firefighters remain stationary throughout this process. In this talk, we consider a variation where we allow the firefighters to move. We present an integer program for this variation, and prove a containment theorem for the lattice $\mathbb{Z} \times \mathbb{Z}$. This is joint work with students Lise Holte and Ryan Wagner. (Received September 13, 2012)

1086-VN-863 **André Kündgen and Alex Toole*** (toole002@cougars.csusm.edu), 320 Talon Ridge Way Apt #372, Oceanside, CA 92058. *Nonrepetitive Colorings of Grid Graphs*. A *Nonrepetitive coloring* of a graph is a coloring of its vertices such that there are no paths for which the color pattern of the first half is repeated on the second half. In this talk we will give a brief history of nonrepetitive graph colorings, as well as bounds on the number of colors required for a specific class of graphs, the grid graphs. For example, the $2 \times n$ grid has a nonrepetitive coloring using at most 5 colors, and 5 colors are necessary when n is at least 9. (Received September 14, 2012)

1086-VN-986 **Shannon R Overbay*** (overbay@gonzaga.edu). *Generalizations of Book Embeddings to Books with Modified Pages and Spines*. Preliminary report. A standard n -book is a line in 3-space (the spine), together with n half-planes (the pages), joined together at the spine. A graph is embedded in a book by ordering the vertices along the spine and placing the edges within the pages of the book so that no two edges cross each other or the spine. The book-thickness of a graph, G , is the smallest number of pages needed to embed G in a book. In this paper, we consider modifications of the standard book. The first modification permits edges to wrap from one side of the page to the other and the second allows the spine to be a tree. We present optimal edge bounds for these modified books. (Received September 17, 2012)

1086-VN-998 **Serge C Ballif***, serge.ballif@nsc.edu. *Mutually Orthogonal Latin Squares via Polynomials Modulo n* . A latin square of order n is an $n \times n$ square where each row and column is a permutation of the same set of n numbers. Two latin squares of the same order are said to be orthogonal if whenever two cells have the same entry in one square, they have distinct entries in the other square. We say that a latin square is a polynomial latin square if the entry in row x and column y is $f(x, y)$ where f is a polynomial in $\mathbb{Z}_n[x, y]$. We extend a result of Rivest by showing that if p is the smallest prime dividing n , there can be at most $p - 1$ pairwise orthogonal polynomial latin squares of order n . (Received September 17, 2012)

1086-VN-1034 **Jeremy L. Martin and Jennifer D. Wagner*** (jennifer.wagner1@washburn.edu), Washburn University, 1700 SW College Ave., Topeka, KS 66621. *On the spectra of simplicial rook graphs*. The *simplicial rook graph* $SR(d, n)$ is the graph whose vertices are the lattice points in the n th dilate of the standard simplex in \mathbb{R}^d , with two vertices adjacent if they differ in exactly two coordinates. We prove that the adjacency and Laplacian matrices of $SR(3, n)$ have integral spectrum for every n . The proof proceeds by calculating an explicit eigenbasis. We conjecture that $SR(d, n)$ is integral for all d and n , and present evidence in support of this conjecture. For $n < \binom{d}{2}$, the evidence indicates that the smallest eigenvalue of the adjacency matrix is $-n$, and that the corresponding eigenspace has dimension given by the Mahonian numbers, which enumerate permutations by number of inversions. (Received September 18, 2012)

- 1086-VN-1073 **Katherine Benson*** (katherine-f-benson@uiowa.edu), 14 MacLean Hall, University of Iowa, Iowa City, IA 52242. *Improved Lower Bounds of Radio Numbers for Some Trees.* Preliminary report.

A radio labeling of a simply connected graph G with diameter D is a function $f : V(G) \rightarrow \mathbb{Z}^+$ such that for every two distinct vertices u and v of G , the radio condition, $d(u, v) + |f(u) - f(v)| \geq D + 1$, is satisfied. The radio number of a graph G is the smallest integer m for which there exists a radio labeling f with $f(v) \leq m$ for all $v \in V(G)$. In this talk, we will establish a method for finding a reasonable lower bound for the radio number of certain types of tree graphs. (Received September 18, 2012)

- 1086-VN-1078 **Ralph P. Grimaldi*** (grimaldi@rose-hulman.edu), Professor Ralph P. Grimaldi, Mathematics Dept. RHIT, 5500 Wabash Avenue, Terre Haute, IN 47803. *Up-Down Sequences: Inversions, Coinversions, and the Sum of the Major Indices.*

For $n \geq 1$, let a_n count the number of up-down sequences s_1, s_2, \dots, s_n , where (i) $s_1 = 1$; (ii) $s_i \in \{1, 2, 3, 4\}$, for $2 \leq i \leq n$; and, (iii) $|s_i - s_{i-1}| = 1$, for $2 \leq i \leq n$.

One finds that $a_n = F_n$, the n -th Fibonacci number.

If s_1, s_2, \dots, s_n is a given up-down sequence, we say that (1) an inversion occurs whenever there are integers i, j where $1 \leq i < j \leq n$ but $s_i > s_j$; and, (2) a coinversion occurs whenever there are integers i, j where $1 \leq i < j \leq n$ and $s_i < s_j$.

We determine formulas for the numbers of inversions and coinversions that occur among these F_n sequences.

Finally, for an up-down sequence s of length n , we say that a descent occurs at position i , for $1 \leq i \leq n - 1$, if $s_i > s_{i+1}$, and we let $Des(s)$ be the set of all such positions. The major index of s is then the sum of all the entries in $Des(s)$. Our final result is a formula for the sum of the major indices for all F_n up-down sequences of length n . (Received September 18, 2012)

- 1086-VN-1131 **Diana L Smith*** (diana@math.uri.edu). *Defective (3,0,0)-colorings of planar graphs with no 4- or 5-cycles.*

Steinberg's conjecture that every planar graph without 4- or 5-cycles is 3-colorable is still open, although much work has been done leading up to a solution. This problem was relaxed by Raspaud, Chang, Havet, and Montassier (2012) by considering near-colorings of these graphs. A graph is said to be (s_1, s_2, s_3) -colorable if its vertex set can be colored by three colors $(1, 2, 3)$ such that the subgraph induced by the i^{th} color class has degree at most s_i for $i = 1, 2, 3$. Raspaud et al. proved every planar graph without 4- or 5-cycles is $(2, 1, 0)$ -colorable as well as $(4, 0, 0)$ -colorable. We prove in this paper that every such graph is in fact $(3, 0, 0)$ -colorable. (Received September 19, 2012)

- 1086-VN-1220 **Jennifer McLoud-Mann*** (jmcloud@uttyler.edu), 3900 University Blvd., Tyler, TX 75799, and **Christina Graves** (cgraves@uttyler.edu), 3900 University Blvd., Tyler, TX 75799. *Side lengths of pseudoconvex fullerene patches.*

In this paper we consider fullerene patches with nice boundaries containing between one and five pentagonal faces. We find necessary conditions for the side lengths of such patches, and then prove these conditions are sufficient by constructing such patches. (Received September 20, 2012)

- 1086-VN-1410 **Vesta Coufal, Rob Ray and John J. Villalpando*** (jvillalp@callutheran.edu), California Lutheran University, 60 West Olsen Road, Thousand Oaks, CA 91360, and **Kathi A. Yerion**. *The minimum cardinality of the range of irreducible $L(2,1)$ Colorings.*

An $L(2,1)$ coloring of a graph is a mapping from the vertex set of a graph to the non-negative integers such that integers on adjacent vertices differ by at least two, and integers on vertices distance two apart differ by at least one. We consider the added irreducibility restriction that at no vertex can the integer be decreased without violating these $L(2,1)$ coloring requirements. Define κ , the irreducible $L(2,1)$ coloring number of a graph, to be the least number of distinct integers required to produce such a coloring of the graph. We determine κ for various classes of graphs. (Received September 21, 2012)

- 1086-VN-1463 **Shaun Sullivan***, 3285 Cypress Legends Cir., #903, Fort Myers, FL 33965-6565. *Fine Ballot Numbers.*

The ballot numbers count paths that stay weakly above the diagonal $y = x$, start at the origin, and take steps from the set $\{\uparrow, \rightarrow\} = \{u, r\}$. Those ending on the diagonal can be viewed as Dyck paths. The Fine Numbers count Dyck paths with no hills, that is paths with no ur on the diagonal. We consider ballot paths with no hills, and ballot paths with k hills. Using Finite Operator Calculus, we can find a formula to enumerate ballot paths

with k hills. We also generalize the result that the ratio of Fine numbers to Catalan numbers approaches $\frac{4}{9}$ to Dyck paths with k hills.

Keywords: Finite Operator Calculus, Umbral Calculus, Dyck paths (Received September 22, 2012)

1086-VN-1720 **Noah Streib*** (noah.streib@nist.gov). *Dimension-Preserving Contractions and a Finite List of 3-Irreducible Posets.*

We introduce two new operations on partially ordered sets (posets). These operations can be used to transform a poset P into a simpler poset Q such that the dimension is unchanged as a result of the transformation. We call these operations *dimension-preserving contractions*. As an application, these contractions can be used to shrink the well-known infinite list of 3-irreducible posets to a list of 3-irreducible, non-contractible posets of size seventeen (up to duality). (Received September 24, 2012)

1086-VN-1750 **Casey Mann*** (cmann@uttyler.edu), The University of Texas at Tyler, Department of Mathematics, 3900 University Blvd, Tyler, TX 75799, and **Ali Chick**. *Equilaterally k -Isotoxal Tiles*. Preliminary report.

A tiling \mathcal{T} of the plane is *k-isotoxal* if every edge of \mathcal{T} can be mapped to any other edge of \mathcal{T} by a symmetry of \mathcal{T} . We define a tile T to be *k-isotoxal* if every tiling admitted by T is *k-isotoxal*. Trivially, any tile that has k congruence classes of edges is *n-isotoxal* for $n \geq k$. Therefore, we restrict attention to *equilateral tiles* (i.e. tiles whose edges are all congruent to one another). Lastly, an *equilaterally k-isotoxal* tile is one that is equilateral and admits only *k-isotoxal* tilings of the plane. In this talk we present examples of equilaterally *k-isotoxal* tiles for $k = 1, 2$, and 3 . (Received September 24, 2012)

1086-VN-1843 **Taylor Kindred*** (tkindred@students.kennesaw.edu). *Total Domination on the Triangular Honeycomb Chessboard*. Preliminary report.

A set $S \subseteq V$ is a dominating set of a graph $G = (V, E)$ if each vertex in V is either in S or is adjacent to a vertex in S . A vertex is said to dominate itself and all its neighbors. The domination number, $\gamma(G)$, is the minimum cardinality of a dominating set of G . When translated to a chessboard puzzle, the domination question is how to threaten or occupy every square on the board with the fewest number of pieces. In the 1996 MAA publication, *Which Way Did the Bicycle Go?*, Konhauser, Velleman, and Wagon defined the triangular honeycomb chessboard of side n . In 2012, DeMaio and Tran computed domination numbers on the triangular honeycomb board.

A set $S \subseteq V$ is a total dominating set of a graph $G = (V, E)$ if each vertex in V is adjacent to a vertex in S . The total domination number, $\gamma_t(G)$, is the minimum cardinality of a total dominating set of G . Translated to the chess board, occupying a space is no longer sufficient. Every space must be threatened. This talk begins the analysis of total domination numbers for the triangular honeycomb chessboard. (Received September 24, 2012)

1086-VN-1934 **Emily A Sasala*** (sasalaea@jay.washjeff.edu), Mathematics Department, Washington & Jefferson College, Washington, PA 15301, and **Roman Wong**. *Independent Sets in Chain Paths and Cycles*.

It is known that the number of independent sets in path graphs and cycle graphs are related to Fibonacci numbers and Lucas numbers. We defined a chain path $P_{n,k}$ to be a path P_n with additional paths P_k , at each vertex. A chain cycle is defined similarly. In this talk we investigate independent sets and maximal independent sets in chain paths and cycles. We derive the recursive formulas and the explicit formulas for the number of independent sets in these graphs. (Received September 24, 2012)

1086-VN-1956 **Manda Riehl*** (riehlar@uwec.edu). *Distribution of distances under the Double Cut and Join model of genome rearrangement*.

The Double Cut and Join model of genome rearrangement has the unique property that distances between genomes can be calculated via bipartite adjacency graphs. We answer the following question: How many genomes of length n are distance k from a starting genome A ? We accomplish this by finding the number of these adjacency graphs with certain properties. We also show the resulting distance distributions for various starting genomes A . (Received September 24, 2012)

1086-VN-2115 **Janine E. Janoski*** (janinejanoski@kings.edu), **Neil J. Calkin**, **Allison Nelson**, **Sydney Ryan** and **Chao Xu**. *Sprague-Grundy Numbers for Nim on Graphs*.

We discuss the game of Nim played on various graphs. The game is played by selecting a vertex and removing some subset of edges from that vertex. The player to remove the last edge of the graph wins. We analyze the Sprague-Grundy numbers for generalized spider graphs. (Received September 24, 2012)

- 1086-VN-2137 **David Offner***, Westminster College, New Wilmington, PA 16172, and **Kerry Ojakian**, Bronx Community College (CUNY), Bronx, NY 10453. *A new lower bound for a variation of Cops and Robber on the hypercube, with an application to Graph Searching.*

The game of Cops and Robber is a two-player, perfect-information game played on an undirected graph G . A robber and a fixed number of cops each occupy vertices of G , and take turns moving to adjacent vertices. The cops win if a cop ever occupies the same vertex as the robber. The cop number is the minimum number of cops required to guarantee a winning strategy for the cops, and this number can be interpreted as a measure of the difficulty of searching the graph. In this talk, we give a new lower bound on the cop number for the n -dimensional hypercube in the variation of the game where only one cop is allowed to move on each turn. Additionally, we connect Cops and Robber to another class of vertex pursuit games, Graph Searching, where any number of cops may move on a turn, but the robber is not visible to the cops, and may be infinitely fast. Our result also provides a new lower bound for the cop number in this setting. (Received September 25, 2012)

- 1086-VN-2166 **Wing Hong Tony Wong*** (tonywong@caltech.edu), MC 253-37, Department of Mathematics, California Institute of Technology, Pasadena, CA 91125, and **Richard M Wilson** (rmw@caltech.edu), MC 253-37, Department of Mathematics, California Institute of Technology, Pasadena, CA 91125. *Diagonal forms for incidence matrices and zero-sum Ramsey theory.*

Let H be a t -uniform hypergraph on k vertices, with $a_i \geq 0$ denoting the multiplicity of the i -th edge, $1 \leq i \leq \binom{k}{t}$. Let $\mathbf{h} = (a_1, \dots, a_{\binom{k}{t}})^T$, and $N_t(H)$ the matrix whose columns are the images of \mathbf{h} under the symmetric group S_k . We determine a diagonal form (Smith normal form) of $N_t(H)$ for a very general class of H .

Now, assume H is simple. Let $K_n^{(t)}$ be the complete t -uniform hypergraph on n vertices, and $R(H, \mathbb{Z}_p)$ the zero-sum (mod p) Ramsey number, which is the minimum $n \in \mathbb{N}$ such that for every coloring $c: E(K_n^{(t)}) \rightarrow \mathbb{Z}_p$, there exists a copy H' isomorphic to H inside $K_n^{(t)}$ such that $\sum_{e \in E(H')} c(e) = 0$. Through finding a diagonal form of $N_t(H)$, we reprove a theorem of Y. Caro that gives the value $R(G, \mathbb{Z}_2)$ for any simple graph G . Further, we show that for any t , $R(H, \mathbb{Z}_2)$ is almost surely k as $k \rightarrow \infty$, where k is the number of vertices of H .

Similar techniques can also be applied to determine the zero-sum (mod 2) bipartite Ramsey numbers, $B(G, \mathbb{Z}_2)$, introduced by Caro and Yuster. (Received September 24, 2012)

- 1086-VN-2171 **Mari F Castle***, mfc7379@kennesaw.edu, and **Joe DeMaio** and **Keegan Gary**. *Total Efficient Dominating Sets in Cayley Graphs of Dihedral Groups.*

A set $S \subseteq V$ is a **total efficient dominating set (TEDS)** of a graph $G = (V, E)$ if each vertex in V is adjacent to exactly one vertex in S . From the work of Gavlas and Schultz we have that a TEDS S exists on the path graph P_n if and only if $n \not\equiv 1 \pmod{4}$, and that a TEDS S exists in the cycle graph, C_n , if and only if $n \equiv 0 \pmod{4}$. A **circulant graph** $\text{Circ}(n; X)$ is defined for a positive integer n and a subset X of the integers $1, 2, \dots, \lfloor \frac{n}{2} \rfloor$, called the **connections**. The vertex set is \mathbb{Z}_n , and there is an edge joining two vertices j and k if and only if the difference $|j - k|$ is in the set X . A circulant graph is a special case of a Cayley graph. DeMaio and Castle have shown that for all positive integers n and k , such that $2k \mid n$ there exists a set C of order k such that $G(\mathbb{Z}_n, C)$ admits a TEDS S . In this talk we will extend this result to Cayley graphs of dihedral groups. (Received September 24, 2012)

- 1086-VN-2175 **Hollis Brewer***, hbrewer1@students.kennesaw.edu, and **Mari F. Castle** and **Joe DeMaio**. *Total Efficient Dominating Sets in Cayley Graphs of Finite Abelian Groups.*

A set $S \subseteq V$ is a **total efficient dominating set (TEDS)** of a graph $G = (V, E)$ if each vertex in V is adjacent to exactly one vertex in S . From the work of Gavlas and Schultz we have that a TEDS S exists on the path graph P_n if and only if $n \not\equiv 1 \pmod{4}$, and in the cycle graph, C_n , if and only if $n \equiv 0 \pmod{4}$. Let H be a finite group with identity e . Let C be a subset of H satisfying $e \notin C$ and $C = C^{-1}$, that is, $a \in C$ if and only if $a^{-1} \in C$. The **Cayley graph** on H with **connection set** C , denoted $G(H, C)$, satisfies: the vertices of $G(H, C)$ are the elements of H ; there is an edge joining $a, b \in G(H, C)$ if and only if $a^{-1}b \in C$. For the dihedral group D_n of size $2n$, DeMaio and Castle have shown that a TEDS S exists in $G(D_n, C)$ if and only if $k \mid n$ where $|C| = k$. In this talk we will extend this result to Cayley graphs of finite abelian groups. (Received September 25, 2012)

- 1086-VN-2184 **John Portin*** (jportin@linfield.edu), **Alexander Sistko**, **Luke Naftz**, **Tyler Hays**, **Nino Barrett**, **Susan Rufai**, **Jennifer Firkins-Nordstrom** and **Chuck Dunn**. *The 1-relaxed game chromatic number of complete multipartite semi-Hamiltonian graphs.*

For a finite graph G , a non-negative integer d and a positive integer k , we define a game on G played by two players, Alice and Bob, who alternately colors the uncolored vertices of G . In the d -relaxed game a color α is legal for the vertex v if after v is colored alpha, the subgraph induced by all of the α colored vertices has maximum

degree at most d . Alice wins the game if every vertex in G can eventually be colored. Otherwise, bob wins. The least k such that Alice has a winning strategy is called the d -relaxed game chromatic number. The 0-relaxed game chromatic number of complete multipartite graphs is known, and the 1-relaxed game chromatic number of complete multipartite graph is known for special graphs. We will show the 1-relaxed game chromatic number of complete multipartite semi-Hamiltonian graphs is $\lceil |G|/2 \rceil$ where $|G|$ is the size of the vertex set of G , and give criteria for determining whether a complete multipartite graph is semi-Hamiltonian. (Received September 25, 2012)

1086-VN-2203 **Gary F. Tiner*** (gtiner@faulkner.edu), 5345 Atlanta Hwy., Montgomery, AL 36109, and **Nancy Eaton**.

If G is a graph with average degree greater than $k - 2$, Erdős and Gallai proved that G contains a path on k vertices. Erdős and Sós conjectured that under the same condition, G should contain every tree on k vertices. Several results based upon the number of vertices in G have been proven including the special cases where G has exactly k vertices (Zhou), $k + 1$ vertices (Slater, Teo and Yap), $k + 2$ vertices (Woźniak) and $k + 3$ vertices (the second author of this paper). To strengthen these results, we will prove the Erdős-Sós conjecture holds if a longest path in G has at most $k + 3$ vertices (no restriction is imposed on the number of vertices of G). (Received September 25, 2012)

1086-VN-2243 **Peter Adams** (p.adams@uq.edu.au), **Darryn E Bryant** (db@maths.uq.edu.au), **Saad I El-Zanati*** (saad@ilstu.edu) and **Wannasiri Wannasit** (nasit049@yahoo.com). *On the spectrum problem for cubic graphs of order 8.*

Let H and G be graphs such that G is a subgraph of H . A G -decomposition of H is a set $\Delta = \{G_1, G_2, \dots, G_t\}$ of pairwise edge-disjoint subgraphs of H each of which is isomorphic to G and such that $E(H) = \bigcup_{i=1}^t E(G_i)$. A G -decomposition of K_m is also known as a (K_m, G) -design. The problem of determining all values of m for which there exists a (K_m, G) -design is commonly called the *spectrum problem for G* . We settle the spectrum problem for cubic graphs of order 8 by showing that if G is a cubic graph of order 8, then there exists a (K_m, G) -design if and only if $m \equiv 1$ or $16 \pmod{24}$. (Received September 25, 2012)

1086-VN-2374 **Natacha C. Fontes-Merz*** (fontesnc@westminster.edu), **Jeffrey T. Boerner** (boernej@westminster.edu) and **James Anthony** (anthonj@westminster.edu). *Adding Edges to Graphs and its Effect on the Pebbling Number.* Preliminary report.

In this talk we discuss graphs whose pebbling number remains unchanged when an edge is added between nonadjacent vertices. We will give examples of constant graphs, i.e. graphs in which the addition of some edge does not change the pebbling number, and examples of pure constant graphs, graphs in which the addition of any edge does not change the pebbling number. We determine which trees are constant and we present a class of trees which are pure constant. (Received September 25, 2012)

1086-VN-2385 **Demitri J. Plessas*** (demitri.plessas@umontana.edu), Department of Mathematical Sciences, 32 Campus Drive, Missoula, MT 59812. *Topos Axioms and the Categories of Graphs.*

In the usual Category of Graphs, the graphs allow only one edge to be incident to any two vertices, not necessarily distinct. The usual graph morphisms must map edges to edges and vertices to vertices while preserving incidence. We refer to these morphisms as strict morphisms. We relax the condition on the graphs allowing any number of edges to be incident to any two vertices, as well as relaxing the condition on graph morphisms by allowing edges to be mapped to vertices, provided that incidence is still preserved. We call this broader graph category the Category of Conceptual Graphs, and define three other graph categories created by combinations of restrictions of the graph morphisms as well as restrictions on the allowed graphs. These categories have finite limits and colimits (the first of the three topos axioms). We explore the other two topos axioms: the existence of exponentiation with evaluation and/or a subobject classifier. It is known that the usual Category of Graphs is cartesian closed but lacks a subobject classifier. We show there is another category of graphs that is also cartesian closed but lacks a subobject classifier. We also show that the remaining three categories lack exponentiation with evaluation, but do have subobject classifiers. (Received September 25, 2012)

- 1086-VN-2440 **Rigoberto Florez*** (rigo.florez@citadel.edu), 171 Moultrie St., Dept of Mathematics and Computer Science, The Citadel, Charleston, SC 29409, **Eva Czabarka** (czabarka@math.sc.edu), Dept of Mathematics, LeConte College, University of South Carolina, 1523 Greene Street, Columbia, SC 29208, and **Leandro Junes** (junes@calu.edu), 250 University Ave, Dept of Mathematics, Computer Science, California, PA 15419. *Convolutions on the Geometry of Hosoya's Triangle*. Preliminary report.

The generalized Hosoya's triangle is an arrangement of numbers where each entry is a product of two generalized Fibonacci numbers. We define a discrete convolution based on the entries of generalized Hosoya's triangle.

Using generating functions we prove that this convolution is a combination of generalized Fibonacci numbers and Lucas numbers. We discuss how a simple formula, resulting from a particular case of the convolution, applies to count words in formal languages. (Received September 25, 2012)

- 1086-VN-2449 **Elizabeth Beazley, Margaret Nichols, Min Hae Park, XiaoLin Shi and Alexander Youcis*** (ayoucis@terpmail.umd.edu). *Projections on Parabolic Quotients of Affine Weyl Groups*.

Affine Weyl groups and their parabolic quotients are used extensively as indexing sets for objects in representation theory, algebraic geometry, and number theory. Moreover, we can conveniently realize the elements of certain quotients via intuitive geometric and combinatorial models such as abaci, alcoves, root lattice points, and core partitions. Berg, Jones, and Vazirani have described a bijection between n -cores with first part equal to k and $(n-1)$ -cores with first part less than or equal to k . This bijection also has an interpretation in terms of the correspondence of Lapointe and Morse between n -cores and $(n-1)$ -bounded partitions. This correspondence played a crucial role in the development of k -Schur functions, which are known to represent the Schubert basis in the homology of the affine Grassmannian. In this talk we discuss how to generalize this bijection of Berg, Jones, and Vazirani to parabolic quotients of affine Weyl groups in other classical Lie types. We have developed not only combinatorial techniques to describe this map, but also a visually explicit method utilizing the geometric properties of the alcove model coming from the root system associated to the affine Weyl group. (Received September 25, 2012)

- 1086-VN-2486 **Mary J. Riegel*** (riegelmj@mso.unt.edu). *On a Dynamic Positional Game*. Preliminary report.

Tic-Tac-Toe is a well know, often played, and frequently studied game. As the prototypical positional game, its analysis highlights many of the characteristics that one looks for in the study of positional games. Many variations to the game exist, and in this talk we will explore a dynamic version of the game played on various boards, that is, a game in which pieces are allowed to move. Possible boards we will discuss include finite affine and projective planes, matroids and classes of matroids, as well as new boards constructed from smaller boards. In particular we will discuss how to use weight functions to determine strategies for the players in our dynamic game. We will also discuss outcome classes for various types of boards. We recall that in Tic-Tac-Toe, Player 2 has a drawing strategy. That is, under optimal play the second player can prevent Player 1 from winning. For some of our classes of boards we will discuss bounds on the size of a board sufficient to ensure that Player 2 has a drawing strategy. (Received September 25, 2012)

- 1086-VN-2564 **Andrew C Lee*** (andrew.lee2@usma.edu), 3320 E. Continental Rd, West Point, NY 10996. *Optimized Routing of Unmanned Aerial Systems to Address Informational Gaps in Counterinsurgency*.

Recent military conflicts reveal that the ability to assess and improve the health of a society contributes more to a successful counterinsurgency (COIN) than direct military engagement. In COIN, a military commander requires maximum situational awareness not only with regard to the enemy but also to the status of logistical lines of operation (LLO) support concerning civil security operations, governance, essential services, economic development, and the host nation's security forces. By incorporating these LLO targets into the mission planning cycle with a collective UAS effort, commanders can gain a decisive advantage in COIN. Based on the type of LLO, some of these targets might require more than a single observation to provide the maximum benefit. This thesis explores an integer programming and metaheuristic approach to solve the Collective UAS Planning Problem (CUPP). The solution to this problem provides optimal plans for multiple sortie routes for heterogeneous UAS assets that collectively visit these diverse secondary LLO targets while in transition to or from primary mission targets. (Received September 25, 2012)

- 1086-VN-2567 **Chad N Vidden*** (viddenc@uwplatt.edu). *Where Galerkin, Hilbert, and Wilf intersect: an application of the snake oil method for combinatorial sums to finite element method analysis.* Preliminary report.

A new finite element method called the symmetric direct discontinuous Galerkin method for solving diffusion partial differential equations is presented. Within the scheme formulation, there are two free parameters (β_0, β_1) which need to be chosen carefully in order to ensure convergence and accuracy of the method. A notion of numerical flux admissibility is defined to guide the choice of β terms. Analyzing the definition of admissibility leads to an explicit formula used to calculate β terms, but to do so, properties of finite Hilbert matrices need to be shown. To prove Hilbert matrix properties, Wilf's snake oil method for combinatorial sums is used. (Received September 25, 2012)

- 1086-VN-2632 **Amanda J Watkins Niedzialomski*** (amanda-watkins@uiowa.edu). *Cartesian powers of graphs and consecutive radio labelings.*

For $k \in \mathbb{Z}^+$, a k -radio labeling f of a graph requires all pairs of distinct vertices u and v to satisfy $|f(u) - f(v)| \geq k + 1 - d(u, v)$. When $k = 1$, this requirement gives rise to the familiar labeling known as vertex coloring for which each vertex of a graph is labeled so that adjacent vertices have different "colors". We consider k -radio labelings of G when $k = \text{diam}(G)$. In this setting, no two vertices can have the same label, so graphs that have radio labelings of consecutive integers are one extreme on the spectrum of possibilities (because they use the smallest labels). Examples of such graphs of high diameter are especially rare and desirable. We construct examples of arbitrarily high diameter using the Cartesian product of graphs. (Received September 25, 2012)

- 1086-VN-2700 **Kathleen M Ryan*** (kmr207@lehigh.edu), Lehigh University Mathematics Department, 14 East Packer Avenue, Bethlehem, PA 18015, and **Garth Isaak**. *Degree Vector Sequences of Edge-Colored Graphs in Specified Families.*

The degree vector of a vertex v in an edge-colored graph is the column vector in which entry i indicates the number of edges of color i incident to v . Given a set of column vectors \mathcal{C} and a graph family \mathcal{F} , when does there exist some edge-colored graph in \mathcal{F} whose set of degree vectors is \mathcal{C} ? This question is NP-Complete in general but certain graph families yield tractable results. We present results on the families we have considered, such as $n \times m$ grids, 2-trees, and a disjoint union of paths and cycles. (Received September 25, 2012)

- 1086-VN-2702 **Franklin Hardin Jones Kenter***, 9500 Gilman Drive; MC 0112, La Jolla, CA 92093, and **Fan Chung**. *Isoperimetric Inequalities for Directed Graphs.*

We establish several discrepancy and isoperimetric inequalities for directed graphs by considering the associated random walk. We show that various isoperimetric parameters, as measured by the stationary distribution of the random walks, including the Cheeger constant and discrepancy are related to the singular values of the normalized probability matrix and the normalized Laplacian. Further, we consider the *skew-discrepancy* of directed graphs which measures the difference of flow among two subsets. We show that the skew-discrepancy is intimately related to \mathcal{Z} , the skew-symmetric part of the normalized probability transition matrix. In particular, we prove that the skew-discrepancy is within a logarithmic factor of $\|\mathcal{Z}\|$. Finally, we apply our results to construct extremal families of directed graphs with large differences between the discrepancy of the underlying graph and the skew-discrepancy. (Received September 25, 2012)

- 1086-VN-2768 **A. Scott Duane*** (adrian.duane@gmail.com) and **Jeff Remmel**. *Counting consecutive patterns in up-down permutations using the maximum packing number.*

Let A_{2n} denote the set of up-down alternating permutations of length $2n$. For a sequence of distinct integers $\sigma_1, \dots, \sigma_{2n}$, we define $\text{red}(\sigma)$ to be the sequence that results from replacing the i th smallest integer in σ by i . We say that an alternating permutation π has a τ -match at position i if $\text{red}(\pi_i, \dots, \pi_{i+2j-1}) = \tau$, where $|\tau| = 2j$. We define $\tau\text{-mch}(\sigma)$ to be the number of τ -matches in an alternating permutation σ . Furthermore, we say that τ has the *minimal overlapping property* if two τ -matches in an alternating permutation π can share at most two letters.

Let τ be an up-down alternating permutation with the minimal overlapping property. We derive the generating function

$$\sum_{n \geq 0} \frac{t^n}{n!} \sum_{\sigma \in A_{2n}} x^{\tau\text{-mch}(\sigma)} = \frac{1}{1 + \sum_{n \geq 1} \frac{t^{2n}}{(2n)!} GMP_{\tau, 2n}(x)}$$

where $GMP_{\tau, 2n}(x)$ is the *generalized maximum packing polynomial*. We define this polynomial and give examples of patterns τ for which $GMP_{\tau, 2n}(x)$, and, by extension, the generating function above, can be calculated. (Received September 25, 2012)

1086-VN-2787 **Bill Linderman*** (wclinderm@king.edu). *Rook Polynomials*. Preliminary report.

A rook is a chess piece that can move horizontally or vertically, and a rook polynomial is a generating function for the number of ways to place non-capturing rooks on a chessboard. We will demonstrate a method of counting permutations with restricted positions using rook polynomials. (Received September 25, 2012)

1086-VN-2805 **Scott Lacy*** (scott.lacy@mavs.uta.edu). *The ABC's of Property-D Cyclic Neofields*. Preliminary report.

A neofield is a set with two binary operations similar to a field, with the addition not necessarily associative and the multiplication not necessarily commutative. In his seminal paper in 1948 L.J. Paige presented all known results with his own contributions in admissible groups and planar neofields. A.D. Keedwell introduced the notion of Property-D cyclic neofields primarily to explain the non-existence of orthogonal latin squares of order 6. In this survey talk we will examine the conjecture that such neofields exist for all finite orders except for 2 and 6. (Received September 25, 2012)

1086-VN-2864 **Janet L. Fiererson*** (fiererson@lasalle.edu), Dept. of Mathematics and Computer Science, La Salle University, 1900 W. Olney Ave., Philadelphia, PA 19141, and **Kristen Heaney**. *An extension of the (strong) rainbow connection number*. Preliminary report.

(Strong) rainbow connection is a concept introduced by Chartrand et al. (2008) in the area of graph coloring. The (strong) rainbow connection number of a connected graph G is the minimum number of colors required to color the edges of G in such a way that every pair of vertices is connected by a rainbow (shortest) path, a (shortest) path with no two edges assigned the same color. Many recent papers have addressed this topic and its relationship to other graph properties.

(Strong) rainbow connection finds applications in minimization problems in areas such as networking and secure transfer of information. The motivation for our work is a desire for further optimization. Building on the foundation of the (strong) rainbow connection number of a graph, we introduce a new concept. We present results for several specific classes of graphs, discuss general relationships and conclusions, and introduce potential areas for future research. (Received September 25, 2012)

1086-VN-2900 **Jessie A. Deering*** (deeringj@goldmail.etsu.edu), **Teresa W. Haynes** (haynes@etsu.edu), **Stephen T. Hedetniemi** and **William Jamieson**. *Downhill Domination Numbers of Graphs*.

A path $\pi = v_1, v_2, \dots, v_{k+1}$ in a graph $G = (V, E)$ is a *downhill path* if for every i , $1 \leq i \leq k$, $\deg(v_i) \geq \deg(v_{i+1})$, where $\deg(v_i)$ denotes the degree of vertex $v_i \in V$. The *downhill domination number* $\gamma_d(G)$ equals the minimum cardinality of a set $S \subseteq V$ having the property that every vertex $v \in V$ lies on a downhill path originating from some vertex in S . We investigate downhill domination numbers and related aspects of downhill paths in graphs. (Received September 26, 2012)

1086-VN-2902 **William B Jamieson*** (jamieson@goldmail.etsu.edu), **Jessie Deering**, **Teresa Haynes** and **Stephen Hedetniemi**. *Uphill Domination in Graphs*.

A path $\pi = v_1, v_2, \dots, v_{k+1}$ in a graph $G = (V, E)$ is a *downhill path* if for every i , $1 \leq i \leq k$, $\deg(v_i) \geq \deg(v_{i+1})$, where $\deg(v_i)$ denotes the degree of vertex $v_i \in V$, and an *uphill path* if for every i , $1 \leq i \leq k$, $\deg(v_i) \leq \deg(v_{i+1})$. The *downhill domination number* $\gamma_d(G)$ equals the minimum cardinality of a set $S \subseteq V$ having the property that every vertex $v \in V$ lies on a downhill path originating from some vertex in S , and the *uphill domination number* $\gamma_u(G)$ equals the minimum cardinality of a set $S \subseteq V$ having the property that every vertex $v \in V$ lies on an uphill path originating from some vertex in S . We investigate uphill domination numbers in graphs and compare results to those of downhill domination numbers in graphs. (Received September 26, 2012)

General Session on Research in Number Theory

1086-VO-370 **Rick Klima*** (klimare@appstate.edu), Appalachian State University, Department of Mathematical Sciences, Boone, NC 28608, and **Neil Sigmon**. *Estimating Success When Combining RSA and the Diffie-Hellman Key Exchange*. Preliminary report.

In the RSA system, a plaintext m , with $0 \leq m \leq n - 1$, is transformed into the ciphertext $m^e \bmod n$, where n is the product of two primes and $\gcd(e, \varphi(n)) = 1$. Since the RSA system is public-key, users can make e public knowledge without compromising security. To break the system, an eavesdropper would have to factor n , a seemingly intractable problem if the prime factors of n were both extremely large. However, being unable to factor n is the only thing preventing an eavesdropper from breaking the system. A method through which it might be possible to keep the system secure even if n were factored is to hold the key e secret, by, for example,

using the Diffie-Hellman key exchange. But there is no guarantee that the Diffie-Hellman key exchange with a non-prime modulus n would result in a value of e that satisfies $\gcd(e, \varphi(n)) = 1$. In this talk, we will discuss and present the result of a large number of simulations estimating the probability that the Diffie-Hellman key exchange with a non-prime modulus n will result in a value of e that satisfies $\gcd(e, \varphi(n)) = 1$. (Received August 26, 2012)

1086-VO-450 **Badih N. Ghusayni*** (bgou@ul.edu.lb). *The Completed Zeta Function and the Riemann Hypothesis*. Preliminary report.

The famous Riemann Hypothesis asserts that all the non-trivial zeros of the zeta function have real part $1/2$. Based on some recent computer calculations showing that the first 10 trillion non-trivial zeros have real part $1/2$, it may be worthwhile to look at some important consequences if the Riemann Hypothesis is true. We then phrase the Riemann hypothesis in terms of the completed zeta function and give results in that direction. (Received September 11, 2012)

1086-VO-532 **Rachel R Insoft*** (rinsoft@wellesley.edu) and **Amanda G Bower** (amandarg@umd.umich.edu). *Mind the Gap: Distribution of Gaps in Generalized Zeckendorf Decompositions*.

Zeckendorf proved that any positive integer can be decomposed into a unique sum of non-adjacent Fibonacci numbers, F_n . Lekkerkerker showed the average number of summands in a decomposition of an integer in $[F_n, F_{n+1})$ is $\frac{n}{\phi^2+1} + O(1)$, where ϕ is the golden mean. Moreover, these two theorems generalize to any positive linear recurrence: $A_n = c_1 A_{n-1} + \dots + c_L A_{n+1-L}$. Further, the number of summands in decompositions for integers in $[A_n, A_{n+1})$ converges to a Gaussian distribution as $n \rightarrow \infty$.

We study the distribution of gaps between summands in generalized Zeckendorf decompositions. We prove that the probability of a gap larger than the recurrence length converges to geometric decay with decay rate equal to the largest root of the characteristic polynomial of the recurrence, and the distribution of smaller gaps depend on the coefficients of the recurrence (which we analyze combinatorially). These techniques work for related systems as well, such as the signed Zeckendorf decomposition. Also, given any integer $m \in [A_n, A_{n+1})$, as $n \rightarrow \infty$ almost surely the gap measure associated to m converges to the average gap measure. (Joint with Olivia Beckwith, Louis Gaudet, Shiyu Li, Steven J Miller, and Philip Tosteson) (Received September 06, 2012)

1086-VO-595 **Virginia A Hogan*** (ginny5hogan@gmail.com), 1125 Fifth Avenue, New York, NY 10128, and **Steven J Miller**. *When Almost All Generalized Sumsets Are Difference Dominated*.

We expect a generic finite set of integers A to have a larger difference set (the set of all differences of elements in A) than sumset because addition is commutative and subtraction is not. In 2009, Hegarty and Miller proved that if elements of $\{0, \dots, N\}$ are chosen independently to be in A with probability $p(N)$ tending to 0, then almost surely A has a larger difference set.

We generalize this to arbitrary combinations of sums and differences. Let h be a positive integer, and choose pairs of integers (s_i, d_i) with $s_i \geq d_i$ and $s_i + d_i = h$. Let each element of $\{0, \dots, N\}$ be independently chosen to be in A with probability $p(N) = N^{-\delta}$. For $\delta \geq \frac{h-1}{h}$, the set $A_{s_i, d_i} = A + \dots + A - A - \dots - A$ (with s_i positive signs and d_i minus signs) with the larger d_i is larger almost surely. There is a phase transition in the behavior when δ passes from exceeding $\frac{h-1}{h}$ to equaling $\frac{h-1}{h}$.

We bound the number of times distinct $h_{(s,d)}$ -tuples generate the same element. This allows us to discount the number of repeated elements in the generalized sumset. We use strong concentration techniques to deal with these obstructions, and from this our result follows. (Received September 08, 2012)

1086-VO-859 **Nicholas George Triantafyllou*** (ngtriant@umich.edu) and **Steven J Miller** (steven.j.miller@williams.edu). *Determinantal Expansions in Random Matrix Theory and Number Theory*. Preliminary report.

We report on recent progress on the n -level densities of low-lying zeros of $GL(2)$ L -functions. We derive an alternate formula for the Katz-Sarnak determinant expansions for test functions with large support that facilitates comparisons between number theory and random matrix theory in orthogonal, symplectic, and unitary settings. Using combinatorics, generating functions, and analysis, we prove these formulas hold and increase the region where number theory and random matrix theory can be shown to agree for holomorphic cuspidal newforms. We also investigate a natural arithmetic conjecture that allows us to derive formulas for test functions with even larger support. (Received September 14, 2012)

- 1086-VO-934 **Donald L. Hitzl*** (domarltd@comcast.net), 7 Candlestick Road, Orinda, CA 94563-3701, and **Frank Zele** (fzele@juno.com), 910 Sharon Park Drive, Menlo Park, CA 94025.
Dynamics of the Riemann Zeta Function.

Two fundamental discoveries will be presented in this paper.

First, for all values of the parameter σ symmetric about the central value $\sigma = 1/2$, it has been found both numerically and analytically that the Magnitude of Zeta is the same, to within an easily computable scale factor, for all values of σ and $1 - \sigma$ (which are automatically symmetric about $1/2$).

Second, by simple partial differentiation with respect to the two independent variables σ and t , it is found that every term in the infinite sum for Zeta satisfies an Undamped Quartic Oscillator PDE. Furthermore, it is found that all infinitely differentiable complex analytic functions (I.e., NOT power series) satisfy a fourth order PDE representing a Damped Oscillator. Two examples are $\Gamma(s)$ and the Riemann Companion Function $\Xi(s)$, where $s = \sigma + it$. (Received September 16, 2012)

- 1086-VO-1031 **Qingxia Li** (liq@lincolnu.edu), 701 S Providence Road, Apt 11, Columbia, MO 65203, and **Matthew Doughty*** (mateo-505@hotmail.com), 914 Carol Street, Jefferson City, MO 65101. *Semisimple Lie Theory and Optimization*. Preliminary report.

In the first part of my presentation, we will discuss the duality framework and convex and non convex sub-differentials in Semisimple Lie Theory. Then we will apply this theory in optimization problems where the controllability is tractable. (Received September 18, 2012)

- 1086-VO-1081 **Kristi Karber*** (kkarber1@uco.edu) and **Rebecca Miller**. *Convergence of the Maximum Zeros of a Class of Fibonacci-Type Polynomials*.

Let a be a positive integer and let k be an arbitrary, fixed positive integer. Define a generalized Fibonacci-type polynomial sequence by $G_{k,0}(x) = -a$, $G_{k,1}(x) = x - a$ and $G_{k,n}(x) = x^k G_{k,n-1}(x) + G_{k,n-2}(x)$ for $n \geq 2$. Let $g_{k,n}$ represent the maximum real zero of $G_{k,n}$. We prove that the sequence $\{g_{k,2n}\}$ is decreasing and converges to a real number β_k . Moreover, we prove that the sequence $\{g_{k,2n+1}\}$ is increasing and converges to β_k as well. We conclude by proving that $\{\beta_k\}$ is decreasing and converges to a . (Received September 18, 2012)

- 1086-VO-1133 **S J Lester*** (sjlester@gmail.com). *a-Points of the Riemann zeta-function on the critical line*.

The roots of $\zeta(s) = a$, where a is a nonzero complex number are known as a -points and have long been an object of study in the theory of the Riemann zeta-function. In this talk we will briefly describe some of their properties and discuss the problem of determining how many a -points lie on the line $\Re(s) = 1/2$. (Received September 19, 2012)

- 1086-VO-1134 **Neranga Fernando*** (wfernand@mail.usf.edu), Department of Mathematics and Statistics, University of South Florida, Tampa, FL, **Xiang-dong Hou**, Department of Mathematics and Statistics, University of South Florida, and **Stephen Lappano**, Department of Mathematics and Statistics, University of South Florida. *New classes of permutation polynomials over finite fields defined by functional equations*. Preliminary report.

Let p be a prime and $q = p^k$. The polynomial $g_{n,q} \in \mathbb{F}_p[x]$ defined by the functional equation

$$\sum_{a \in \mathbb{F}_q} (x+a)^n = g_{n,q}(x^q - x)$$

gives rise to many permutation polynomials over finite fields. We are interested in triples $(n, e; q)$ for which $g_{n,q}$ is a permutation polynomial of \mathbb{F}_{q^e} . We survey recent discoveries of permutation polynomials in form of $g_{n,q}$. In particular, we find that when $n = q^{p+i+1} - q^{2i+1} - 1$, and

$$\left(\frac{2i+1}{q}\right) = \begin{cases} 1 & \text{if } i \text{ is odd,} \\ (-1)^{\frac{q-1}{2}} & \text{if } i \text{ is even,} \end{cases}$$

where $\left(\frac{2i+1}{q}\right)$ is the Jacobi symbol, then $g_{n,q}$ is a permutation polynomial of \mathbb{F}_{q^2} . (Received September 19, 2012)

- 1086-VO-1170 **Thomas C. Occhipinti*** (tocchi@gmail.com), Irvine, CA. *Some Mordell-Weil Groups of Large Rank*.

The existence of elliptic curves of large rank over number fields is an open question, but it has been known for decades that there exist elliptic curves of arbitrarily large rank over global function fields. In this talk we will

discuss some results of Ulmer that showcase the ubiquity of large ranks over function fields, as well as some newer work in the area. (Received September 19, 2012)

1086-VO-1361 **Amanda M Kovacs*** (402 N Woodward Dr., Massapequa, NY 11758). *An Empirical Study on the Iteration of the Total Stopping Time of $3x+1$ Iterates.*

The $3x+1$ conjecture involves the iteration of the Collatz function defined by taking an odd integer n to $(3n+1)/2$ and an even integer n to $n/2$. The total stopping time function $\sigma_\infty(n)$ of a positive integer n is defined to be the minimal number of iterations of the Collatz function needed to reach the value of 1. If no such minimal number exists, then it has a value of ∞ . The $3x+1$ conjecture then states that for all positive integers $n > 1$, $\sigma_\infty(n)$ is finite. There has been much work done on the iteration of the Collatz function, however, very little is known about the iteration of $\sigma_\infty(n)$. With the use of Maple, we investigate the behavior of the iteration of $\sigma_\infty(n)$ and how it compares to the properties of the Collatz function. (Received September 21, 2012)

1086-VO-1503 **Jesse Thorner*** (thorja11@wfu.edu). *Explicit Bounds for Densities Pertaining to Lehmer-Type Questions.*

Given a newform $f \in S_k(\Gamma_0(N))$ with squarefree level N and trivial character, we will present tools that will help provide explicit lower bounds for the density of Fourier coefficients of f which do not equal zero. In particular, we will prove that if f has a Fourier expansion $\sum_{n=1}^{\infty} a(n)q^n$, where $q = e^{2\pi iz}$, and x is a positive number, then

$$\#\{x \leq p \leq 2x : p \text{ prime}, a(p) = 0\} \leq 0.42x^{3/4}$$

for sufficiently large x . This assumes that the symmetric-power L -functions of f are L -functions for which the Generalized Riemann Hypothesis is true. Additionally, using a slightly weaker result, we will prove that if $\tau(n)$ is the Ramanujan tau function, then the density of positive integers for which $\tau(n) \neq 0$ is greater than 0.9999. (Received September 22, 2012)

1086-VO-1591 **Bao Qi Feng*** (bfeng@kent.edu), The Department of Mathematical Sciences, Kent State University at Tuscarawas, New Philadelphia, OH 44663. *There is an infinite number of twin primes: An application of set theory.* Preliminary report.

In this article, we construct a basic set of I_0 :

$$I_0 = \{(\alpha, \alpha + 2) : \alpha \in N\},$$

a set of all pairs of two integers, in which the first coordinate belongs to the natural number set N , and the second coordinator is adding 2 to the first coordinator always. Then, classifying all elements of I_0 by the least prime factor criterion to get an infinite number of nonempty subsets I_k , $k \geq 1$, in I_0 . Let $t_k = \min I_k$, $k \geq 1$. Thus, the process of proving the Conjecture of Twin Primes consists of the following four statements:

1. $I_{k-1} \supset I_k$, $k \geq 1$. It implies the sequence of numbers $\{t_k\}$ is an non-decreasing;
2. Under the condition of $I_k \setminus \{p_{k+1}^2 - 3\} \neq \emptyset$, t_k is a pair twin primes, for all $k \geq 1$;
3. The sequence of numbers $\{t_k\}$ has a strict increasing infinite subsequence;
4. $I_k \setminus \{p_{k+1}^2 - 3\} \neq \emptyset$, for all $k \geq 1$.

(Received September 23, 2012)

1086-VO-1623 **James Lanterman*** (jay.lanterman@gmail.com) and **Jeremiah Reinkoester**. *Irreducible integers under the congruence modulo n relation.*

Building on the general theory of factorization posited by Anderson and Frazier in 2011, for an element a of an integral domain D under an equivalence relation τ , the factorization of a is defined as $\lambda a_1 a_2 a_3 \dots a_k$, where λ is a unit in D and $a_i \tau a_j$ for all i, j . An irreducible element has no *proper* factorization; that is, a factorization in which there is more than one distinct non-unit factor. In this paper, the irreducible integers under the congruence modulo n relation are found for some values of n , and these findings are generalized in the first step toward a general characterization of the irreducible integers under this relation for any prime n . (Received September 23, 2012)

1086-VO-1722 **Aaron M Yeager*** (amydm6@mail.missouri.edu), 1036 Southpark Dr. apt 1, columbia, MO 65201, and **William Banks** (bankswd@missouri.edu) and **Ahmet Güloğlu** (guloglua@fen.bilkent.edu.tr). *Carmichael meets Chebotarev.*

We show that for any finite Galois extension K of the rational numbers \mathbb{Q} , there are infinitely many Carmichael numbers composed solely of primes for which the associated class of Frobenius automorphisms coincides with any given conjugacy class of $\text{Gal}(K|\mathbb{Q})$. This result implies that, for every natural number n , there are infinitely many Carmichael numbers of the form $a^2 + nb^2$ with a, b integers. (Received September 24, 2012)

1086-VO-2059 **Dilum De Silva*** (dilum@ksu.edu), 1540 International Court, Apt #27, Manhattan, KS 66502, and **Chris Pinner**. *Lind-Lehmer constant for groups of the form \mathbb{Z}_p^2 .*

We discuss Lind-Lehmer constant for groups of the form \mathbb{Z}_p^2 , where p is a prime. We first show that we can obtain a nontrivial lower bound for the Lind-Lehmer constant, specifically $\frac{1}{p^2} \log M_2$ for $p \geq 3$, where $M_2 := \min\{a^p \bmod p^2 \mid 2 \leq a \leq p-1\}$. Then we construct an explicit polynomial that attains this minimal value. (Received September 26, 2012)

1086-VO-2362 **Levent Alpoge*** (alpoge@college.harvard.edu) and **Steven J. Miller** (steven.j.miller@williams.edu). *Low-lying zeroes of Maass form L -functions.*

We study the Katz-Sarnak conjecture for the family of Maass forms of large eigenvalue, or large level. Iwaniec, Luo, and Sarnak showed that, on GRH, the family of modular forms of weight k and level N has orthogonal symmetry type, for k or N large. On GL_2/\mathbb{Q} this leaves only the Maass forms, and here there are infinitely many, organized by Laplace eigenvalue and level. We obtain the same result for large eigenvalue or level. (Received September 25, 2012)

1086-VO-2611 **Kevin Vissuet*** (kvissuet@ucsd.edu), 8540 Lemon Ave, La Mesa, CA 91941, and **Steven Miller** (steven.j.miller@williams.edu), 202 Bronfman Science Center, Williamstown, MA 01267. *Most Sets are Balanced in many Finite Groups.*

The sumset is one of the most basic and important objects in additive number theory. Many of the biggest problems (such as Goldbach's conjecture, the Twin Prime conjecture, and Fermat's Last theorem) can be formulated in terms of the sumset $S + S = \{x + y : x, y \in S\}$ of a set of integers S . A finite set of integers A is sum-dominated if $|A + A| > |A - A|$. Though it was believed that the percentage of subsets of $\{0, \dots, n\}$ that are sum-dominated tends to zero, in 2006 Martin and O'Bryant proved a very small positive percentage are sum-dominated if the sets are chosen uniformly at random. Though most sets are difference dominated in the integer case, this is not the case when we take subsets of many finite groups. We show that if we take subsets of larger and larger finite groups, then not only does the probability of a set being sum-dominated tend to zero but the probability that $|A + A| = |A - A|$ tends to one. We also show that in the Dihedral Group case, more sets are sum-dominated than difference-dominated. (Received September 25, 2012)

1086-VO-2728 **Shiyu Li*** (jj12357@berkeley.edu), **Philip D. Tosteson** (philip.d.tosteson@williams.edu) and **Steven J. Miller** (steven.j.miller@williams.edu). *Distribution of the Longest Gap in Positive Linear Recurrence Sequences.*

Throughout mathematics, and in number theoretic systems in particular, results on the spacing of objects have been key to understanding the objects themselves. A couple classic examples are the spacing between zeroes of the Dedekind zeta function, for distribution of primes in a number field, and the spectral gap between the largest two eigenvalues of the adjacency matrix of d -regular graphs.

Zeckendorf showed that every positive integer can be uniquely expressed as a sum of non-adjacent Fibonacci numbers. Beckwith and Miller further demonstrated that, in the limit, the distribution of gaps between summands is geometric. Using combinatorial techniques and probabilistic analysis, we extend this result and prove that the cumulative distribution of the longest gap is a doubly exponential function in the Fibonacci case, with critical value proportional to the logarithm of n for integers near the n^{th} Fibonacci number. The probability of a longest gap rapidly tends to 0 or 1 as we move from this critical value. We then discover, based on this distribution function, a formula for the mean and variance for the spread of longest gaps. (Received September 25, 2012)

1086-VO-2844 **Ping Xu*** (pingxu2@illinois.edu). *An Elementary Proof of Ramanujan's Circular Summation Formula and its Generalizations.*

In this talk, I will give the idea of a completely elementary proof of Ramanujan's circular summation formula of theta functions and its generalizations given by S. H. Chan and Z. -G. Liu, who used the theory of elliptic functions. In contrast to all other proofs, our proofs are elementary. An application of this summation formula is given. (Received September 25, 2012)

1086-VO-2911 **David B. Erf*** (david.erf@pomona.edu) and **Jody Ryker**. *Torsion of Elliptic Curves over Quadratic Fields.*

We present strategies for determining the structure of the torsion subgroup of the Mordell-Weil group of an elliptic curve, E , over quadratic fields. We will use generalizations of the Nagel-Lutz theorem and Mazur's theorem on curves defined over quadratic fields to demonstrate strategies for determining the full torsion subgroup of $E(K)$

for quadratic fields K . Finally, we present an original result describing the possible torsion structures over any quadratic field, K , for the family of elliptic curves given by $E: y^2 = x^3 + a$, for integer a .

Advisor: Benjamin Levitt, REUT at CSU Chico (Received September 26, 2012)

1086-VO-2924 **Henrique Oliveira*** (holiv@math.ist.utl.pt), Mathematics Department, Av. Rovisco Pais, 1, Lisbon, Portugal. *On the distribution of the last digits under the Syracuse iteration.* Lothar Collatz proposed in 1937, with a slightly different formulation, that any natural number under the iteration

$$C(n) = \begin{cases} 3n + 1, & \text{if } n \text{ is odd} \\ \frac{n}{2}, & \text{if } n \text{ is even.} \end{cases}$$

will eventually reach the cycle $\{1, 2\}$. Many authors studied this problem and the Collatz conjecture is also named the $3n + 1$ problem, Ulam conjecture, Kakutani's problem, Hasse's algorithm, Thwaites conjecture or the Syracuse's problem.

In this talk we will prove that under the forward (resp. backward) iterations of $C(n)$ for any initial condition far from the cycle $\{1, 2\}$ the probability distribution of the end digit of $C^m(n)$, for m integer, is uniform for the even numbers and uniform for the odd numbers. The probability distributions for the forward iteration and backward iterations are different due to the non invertible character of the iteration scheme. (Received September 26, 2012)

General Session on Teaching Introductory Mathematics

1086-VP-878 **Thorsten Scheiner*** (thorsten.scheiner@googlemail.com). *The transition from school to university – a transition between two distinct worlds of concept acquisition?*

Both past and recent research point out a series of difficulties students have with the transition from school to university. The initial point is an evaluation study which analyzes the first discontinuity described by Felix Klein. Particular attention is on the two different worlds of concept acquisition. The transition from school to university is seen as a transition from procedures-first construction to concepts-first construction of mathematical concepts. The former is a way of learning of mathematics at school level involving the process of reflective abstraction and the encapsulation of processes as objects, the latter a learning of mathematics at university level involving the manipulation of objects to deduce properties and relationships. Depending on the mathematical way of thinking this shift may require an acquisition of higher-order concepts through conceptual change that universities do not take into account very often. If processes of restructuring prior knowledge are missing before processes of building new knowledge structures take place, unconnected and often incorrect units of knowledge are the effects. This will be shown by a further qualitative study regarding the concept of limit. (Received September 14, 2012)

1086-VP-1016 **Kien H. Lim** (kienlim@utep.edu) and **Art Duval*** (artduval@math.utep.edu), Department of Mathematical Sciences, University of Texas at El Paso, 500 W. University Ave, El Paso, TX 79968-0514, and **Eric Freudenthal** (efreudenthal@utep.edu). *iMPaCT-Math: Fostering Foundational Concepts in Algebra 1 via Programming Activities on Graphing Calculators.*

iMPaCT-Math is a project that involves the development and implementation of a set of learning modules for students learning introductory algebra to make connections across multiple representations: (a) statements in a program, (b) computational process; (c) graphical output, and (d) underlying mathematical concepts. These programming-related activities provide an experiential-visual context for students to engage in mathematical thinking and reinforce foundational concepts like Cartesian coordinates and slopes. Most activities utilize summation within simple programs that can be executed on graphing calculators like TI-83. These programs, and their corresponding graphical outputs, enable students to discover their own math and logic errors in a manner that encourages further investigation or reflection. In this presentation, we will illustrate how writing/modifying simple programs involving "while" loops and anticipating the graphical outputs can reinforce students' understanding of slope and why a constant second difference will cause the graph to curve. Information about our project is available at <http://www.impactstem.org>. (Received September 18, 2012)

- 1086-VP-1185 **Spencer O Sims*** (ssims@laadventistacademy.com), 846 E El Segundo, Los Angeles, CA 90245, and **Kahmya McAlpin**, 846 E El Segundo, Los Angeles, CA 90245. *Using Computer Programming to Teach High School Mathematics*. Preliminary report.

This presentation is a result of a study to answer the following question “can computer programming be used to teach mathematical concepts to high school students?” We highlight various ways that the use of computer programming languages such as C++ and Javascript can impact the learning of certain mathematical concepts in a high school environment. We then consider ways that teachers can use concepts from computer programming to enhance the student’s acquisition of knowledge. (Received September 19, 2012)

- 1086-VP-1320 **Alexander L. Garron; Jr.***, 7127 Spoonfoot St., Orlando, FL 32822. *Constructing an apollonian section parabola, onto a right cone having slope (m) and altitude (A).*

Apollonius never mentioned the parabola focus. I find the principal tool of today’s parabola curve within a right cone using cone slope (m) and altitude (A). Using a CAS, I establish Cartesian two space profile composition of a right cone having slope ($m = 2$). Methods needed to find a section focus require plane geometry, analytic geometry, and linear direction number of three-D space to construct a solid geometry cone consisting of two generators, two diameters for vertex and focus, a principal axis, a focal axis, and the latus rectum. We start with the parabola section vertex on generator ($\pi/2$), and make the section principal axis parallel with generator ($3\pi/2$). Once the section profile and linear ‘skeleton’ is established, I use Sand Box Geometry specific identities and Mathematica to computer generate the solid geometry Apollonius’ parabola section onto the cone surface and isolate the focus of the curve. A view along the (Z) axis will reveal the dual interpretation a parabola curve can present. We will see one vertex, two latus rectum, two foci, all from one Apollonian parabola section locus. I will show that the Apollonian 3-space section curve is actually the source primitive of our two space plane geometry curve providing the focal utility we use today. (Received September 21, 2012)

- 1086-VP-1339 **Salvatore P Giunta*** (sg Giunta@adelphi.edu), Dept. of Math and Comp. Sci., 211 Post Hall, Adelphi University, Garden City, NY 11530. *Trigonometric applets using GeoGebra*.

We present an applet that demonstrates the six trigonometric functions that show how they are related to counterclockwise angles in the unit circle. We will also show how the applet yields values in the standard trigonometric table and show their relation to certain types of triangles. We then present a second applet, analogous to the first, based on the hyperbola that demonstrates the six hyperbolic trigonometric functions and how they are related to values on the hyperbola. By visually displaying these examples side by side, our students may develop a greater understanding of the geometric origins and relationships between these various trigonometric functions. (Received September 21, 2012)

- 1086-VP-1392 **Waclaw Szymanski*** (wszymanski@wcupa.edu), Department of Mathematics, West Chester University, West Chester, PA 19383, and **Ximena Catepillan** (ximena.catepillan@millersville.edu), Mathematics Department, Millersville, PA 17551. *Fundamental Equation for Quadratic Polynomials*. Preliminary report.

A Hindu-Vedic approach to quadratic polynomials, different from and more insightful than the traditional method taught in schools, will be presented. (Received September 21, 2012)

- 1086-VP-1584 **Kayla Bradley Dwelle*** (dwellek@obu.edu), 410 Ouachita Street, Box 3739, Arkadelphia, AR 71923. *What is Mathematics and Why Do We Care?*

It is well known that students begin a liberal arts math course with dread, trepidation and no small amount of skepticism about the benefits. This talk will focus on avenues to draw the students’ attention and interest through well-chosen projects that facilitate mathematical communication and understanding. The presenter has found additional benefits to these projects in the discovery that students connect emotionally and intellectually with the mathematicians and the mathematics they are studying. Overall, the students leave the course with vastly increased appreciation for mathematics and its applications. (Received September 23, 2012)

- 1086-VP-1775 **Dywayne A. Nicely*** (nicely@ohio.edu), Ohio University-Chillicothe, 101 University Drive, Chillicothe, OH 45601. *A Word on Word Problems: How Improving Reading Comprehension and Mathematics Vocabulary Can Improve Performance on Mathematical Word Problems*. Preliminary report.

As instructors of mathematics, we have heard many students declare that they are incapable of solving a word problem or show displeasure when word problems are encountered. Also in recent years, there have been studies that show a correlation between reading comprehension skills and performance on word problems in mathematics courses. Therefore, we are conducting a research project during the 2012-2013 academic year that aims to help students increase their reading comprehension skills, mathematical vocabulary and enhance their

word problem solving strategies. Our obvious hope is that this will increase the students' performance on word problems in their mathematics courses but we also hope to make each student more college-ready. This project is a collaboration between Ohio University-Chillicothe (OU-C) and Chillicothe High School (CHS). Besides me, the project contributors consist of the principal of CHS, and one faculty member each from the English and Mathematics departments of CHS. We are tracking the progress of approximately 125 students from four sections of Algebra II and two sections of Honors Pre-calculus. In this presentation, we discuss an overview of the project's design and present data that has been collected thus far. (Received September 24, 2012)

1086-VP-1889 **Yun Lu***, Mathematics Department, Kutztown University of PA, Kutztown, PA 19530.
Projects in Finite Mathematics Courses.

I teach finite mathematics regularly at my school, and this course focuses on the application of mathematical concepts and methods to problems that arise for students who major in Business or Computer Science. I have used various projects in this course for a couple of years. In this talk I will share some of my experience with the audience including the conduction of the projects, presentation and the evaluation of the students' work, as well as the students' feedback. (Received September 24, 2012)

1086-VP-2558 **Lindsey R. Bosko-Dunbar*** (lboskodunbar@shc.edu), Spring Hill College, 4000 Dauphin St, Mobile, AL 36608. *College Algebra and One Instructor's Attempt to Build a Better Mousetrap.* Preliminary report.

Blackboards are rarely black, the Koala 'bear' is a marsupial, and College Algebra is almost exclusively composed of material taught in high school. The latter misnomer can be an area of continuous struggle for both students and instructors. The students have seen, but not yet mastered the course content. With this, the default for most instructors is to re-teach the course using lecture-based methods that were not successful for the students in their initial algebra course. This talk will focus on the author's experience implementing problem based learning (PBL) in a spring semester College Algebra course after having spent the fall semester lecturing. In addition to specific examples of the topics addressed in the PBL semester, the talk will cover the successes and challenges of such implementation and a general comparison of student achievement between the semesters. (Received September 25, 2012)

1086-VP-2578 **Shenglan Yuan*** (syuan@lagcc.cuny.edu), 31-10 Thomson Ave., LaGuardia Community College, CUNY, Long Island City, NY 11101. *Learning math like a mathematician.* Preliminary report.

In recent years there has been a national push to engage undergraduate STEM majors in experimental math research. Taking on real problems challenges students, stimulates their creativity, and gives them a taste of the kind of work that lies ahead if they choose to continue their math studies. Research centers across the nation offer funding and provide residential research programs for interested.

But for community college students interested in research, there are few opportunities, and little funding. An institutional assumption that significant math maturity is required for research has stymied interested students at two-year colleges. We ask if students should be engaged in research from the beginning of their college career. Rather than teach them math skills so that they can one day do research, perhaps we should engage them in research to help them learn the math skills.

We offer a set of basic questions that will lead to open questions. They require little knowledge of college level math and are crafted to direct undergraduate students (specifically at community colleges) to experiment in a way that will lead to their own discoveries—and to thinking like a mathematician. (Received September 25, 2012)

General Session on Teaching Mathematics Beyond the Calculus Sequence

1086-VQ-25 **Bonface Nyakambi Ongeru*** (bonface.ongeru@yahoo.com), 2732, kisii, Nairobi, nyanza 2732, Kenya. *APPROVAL OF MATHEMATICAL AXIOMS.* Preliminary report.

The formula of giving the sum of any two numbers discovered and would be presented in an expounded form. (Received May 21, 2012)

- 1086-VQ-325 **Ronald M. Brzenk*** (brzenkr@hartwick.edu). *A Capstone Course - Assessed/Revised.* Preliminary report.

My department has transitioned from requiring that our majors complete a senior project (thesis) to requiring that they complete a Senior Capstone course. This paper will report on the current status of the capstone course after three years of assessment and revisions. The learning outcomes for the course will be discussed as well as how student performance and the effectiveness of the new requirement has been assessed. (Received August 21, 2012)

- 1086-VQ-579 **Alex Capaldi*** (alex.capaldi@valpo.edu), 1900 Chapel Drive, Valparaiso, IN 46385. *Teaching Complex Variables with an Inverted Classroom.*

Undergraduate Complex Variables, being a terminal, upper-level mathematics course, is a prime target for using nontraditional pedagogical techniques. One such technique is using an “inverted classroom” teaching style in which the “lecturing” is done at home in the form of reading assignments and/or watching video lectures. This frees class time up to focus on discussion, collaborative work, and engagement with the other activities that are traditionally done outside of class. I used an inverted classroom approach in my Fall 2012 Complex Variables course. I will discuss how I employed the style, the results from grade assessment and student feedback and share anecdotes. (Received September 07, 2012)

- 1086-VQ-1102 **Sarah-Marie Belcastro*** (smbelcas@toroidalsnark.net). *Introducing proof via discrete mathematics (with a twist or two).*

Among the many ways there are to frame and structure courses that focus on introduction to proof, I will offer a significant twist on an existing theme. One part of the existing theme is to frame proofwriting as an ordinary but pervasive part of a content course; I will argue that discrete mathematics provides a superior milieu and the twist will be in the focus and choice of the curriculum. The other part of the existing theme is to structure the course around active learning, so that the types of activities used and the way the text is used support students getting lots of practice in working with proofs.

To succeed in using a content frame and an active learning structure, it is very helpful to use a textbook that is accessible to students and also provides assistance to instructors in creating classes that advance various introduction-to-proof goals. Admission: because I was unable to locate a text that suited me in these regards, I wrote one. I will describe the structure of the textbook and detail how I built into the text ways to help students acquire skills such as analyzing statements, using terminology well, and recognizing where to start in approaching a proof. I’ll also note aspects of the textbook that (attempt to) reflect successful approaches of other texts. (Received September 18, 2012)

- 1086-VQ-1165 **Chad Wiley*** (cwiley1@emporia.edu). *Teaching Advanced Mathematics In An Online Setting.* Preliminary report.

While a wealth of software exists for facilitating a partially or completely online course at the algebra or calculus level, an online course featuring more advanced mathematics must often be constructed from scratch. The purpose of this talk is to discuss the presenter’s experiences teaching graduate mathematics courses online and to discuss some of the software available to make such a course possible. Particular attention will be paid to software which is inexpensive or freely available. (Received September 19, 2012)

- 1086-VQ-1657 **Nathaniel Eldredge*** (neldredge@math.cornell.edu). *Finding applications is the student’s job, or, how to be integrative without really trying: a project-based approach to incorporating other disciplines.* Preliminary report.

When teaching courses that attract students from fields outside mathematics, it is often challenging to find and incorporate applications that are relevant to student interests. I will describe my experience in addressing this challenge through a writing project, in which students seek out and research applications of core course material in their own areas of interest. The project is designed to give them practice in accessing the literature, connecting classroom topics with real-world issues, and communicating their ideas through scientific writing. I will discuss some of the specifics of the assignments I have used, as well as results and possible improvements. (Received September 23, 2012)

- 1086-VQ-1715 **Brian Drake*** (drakebr@gvsu.edu), Mathematics Department, MAK A-2-178, Grand Valley State University, Allendale, MI 49401, and **Feryal Alayont**. *Modeling Mathematical Practice in a Discrete Mathematics Course.*

Whether our students will become professional mathematicians or obtain jobs in industry, they will need developed mathematical abilities to be successful in applying mathematical reasoning to their future jobs and lives. Furthermore, as K-12 education implements the Standards for Mathematical Practice of Common Core State

Standards, our future teacher students will be expected to develop these mathematical abilities in their own students. In this talk, we will describe the strategies we used in a discrete mathematics course to further our students' mathematical abilities. We structured the course to engage students in the process of mathematical inquiry while encouraging discourse on the main mathematical ideas of the course. Students were regularly engaged in inquiry-based activities with individual exploration and group discussion components. Additionally, students participated in a long-term research project involving them in collaborative research. (Received September 24, 2012)

1086-VQ-1749 **Erika L Ward*** (eward1@ju.edu) and **Pam Crawford**. *Engaging Students as Listeners to Enhance Student Oral and Written Communication.*

Mathematics majors at Jacksonville University take two courses that put communication at the forefront. Mathematics and Reasoning (an introduction to proofs class), and History of Mathematics fulfill the university's writing intensive and speaking intensive requirements, respectively. Both classes give students ample opportunities to refine their written and oral skills.

The focus of Mathematics and Reasoning is on writing proofs, but each class period starts with student presentations of their proofs. By engaging in daily practice of presenting mathematics, listening to another's reasoning, and finding ways to give constructive feedback and ask useful questions, students develop critical skills in approaching their own thinking and writing.

In History of Mathematics, students give short general audience talks as well as longer term paper presentations, all evaluated by fellow students and the instructor. Also, students must evaluate three on-campus talks by invited speakers. Students use criteria similar to those used to evaluate their own presentations, developed with a speech instructor. By considering what makes a talk effective as an audience member, students are able to craft better presentations themselves. (Received September 24, 2012)

1086-VQ-1990 **Ricardo Enrique Rojas*** (ricardo.rojas@northern.edu), 1200 South Jay Street, Aberdeen, SD 57401. *Math 351: A Work In Progress.*

The "Introduction to Proofs" course at Northern State University is Math 351 (Foundations of Mathematics). As of January 1st, 2013, I will have taught this course four times. I present both how and why, over the course of several semesters, I have changed how I teach certain topics in Math 351. (Received September 24, 2012)

1086-VQ-2226 **Andrew B Perry*** (aperry@springfieldcollege.edu), MPCs Dept., Springfield College, Springfield, MA 01106. *The Moore Method As Applied To Abstract Algebra.*

At Springfield College in Massachusetts, we had taught Abstract Algebra via a traditional approach for many years and converted to an inquiry-based approach for the past five years. This approach has been a modification of the famous Moore Method popularized by the late R. L. Moore of the University of Texas. We will discuss measurable changes in learning outcomes as well as instructor and student perceptions of the efficacy of the Moore method. (Received September 25, 2012)

1086-VQ-2389 **Horia I Petrache*** (hpetrach@iupui.edu), 402 N. Blackford St., LD154, Physics, IUPUI, Indianapolis, IN 46202. *Coset extensions of real numbers.*

The set of real numbers is extended by using the concept of coset products from group theory. This approach is intended for students with minimal knowledge of group theory but with an interest in number systems. In algebra over fields, various extensions of real numbers are obtained by choosing a base and by specifying multiplication rules for basis elements. Such constructions give rise to the usual complex numbers, quaternions, and so forth. However, the choices of multiplication rules (including the values for structure coefficients) appear ad hoc. Here it is shown that multiplication rules and structure coefficients are obtained naturally from coset group closure and exhaust all possibilities of hypercomplex numbers. The cases corresponding to small groups generating 2, 3, and 4 dimensional number systems will be shown as examples. (Received September 25, 2012)

1086-VQ-2543 **Timothy B Flowers*** (flowers@iupui.edu). *Teaching Elementary Number Theory: Something Old, Something New, Something Borrowed.* Preliminary report.

A course in Elementary Number Theory can be an exciting introduction into accessible yet deep mathematics. However, secondary mathematics education majors or students seeking a degree in applied mathematics may dread it as one of their last "theory" courses. In this talk, we will overview our efforts to get these students interested and engaged in Number Theory. Students were expected to learn about number systems of ancient

cultures, yet also introduced to modern research related to course topics. Methods included discussions, oral presentations, and writing assignments. (Received September 25, 2012)

1086-VQ-2912 **Alessandra Pantano*** (apantano@uci.edu). *Exploring Escher's periodic drawings: A tour of mathematical ideas*. Preliminary report.

This talk will describe the process and outcomes of a MAA-sponsored 6-week full-immersion undergraduate research program conducted at UC Irvine in the summer 2012. Four minorities students, advised by the presenter, were tasked with the project of analyzing symmetry patterns in Escher's periodic drawings. The research touched on many different topics, from group theory to Fourier analysis, exemplifying the power of mathematics as a system of interconnected ideas. For the duration of the project, students worked in a team setting to catalogue Escher's drawings according to their symmetry groups, develop efficient algorithms for image processing, and interpret the data in a Fourier analysis context. This talk will discuss both the mathematical aspects of this NREUP project, including the final successful outcomes, as well as the organizational and logistic issues associated with leading research projects for undergraduate students. (Received September 26, 2012)

1086-VQ-2961 **Craig M. Johnson*** (johnsonc@marywood.edu), Marywood University, 2300 Adams Ave., Scranton, PA 18509. *Using Music to Display Patterns in Geometry and Number Theory*.

Music scores can be used to showcase the use of geometric transformations (translations, reflections, rotations) in musical composition. The pitch classes from which notes are selected also provides an introduction to modular arithmetic and algebra. I distribute selected measures from works by Beethoven, Bach, and Brahms, as well as more modern composers, to students for their analysis and exploration. The questions used attempt to guide the student into identifying some of these concepts on their own. (Received September 26, 2012)

General Session on Assorted Topics

1086-VR-97 **Alejandro R. Garciadiego*** (gardan@unam.mx), Depto Matematicas, Facultad de Ciencias, UNAM, Col. Santo Domingo; Del. Coyoacan, 03700 Mexico, D. F., Mexico, Mexico. *Matemorphosis, an alternative tool for sharing mathematics*. Preliminary report.

The purpose of this talk is to expose the details of a magazine entitled Matemorphosis. This publication aims, in the short run, to permeate an individual, in particular any professor of pre-university level, with an overview of the richness, deepness and universality of mathematical knowledge. In the long run, the reader should acquire a solid and profound comprehension of the subject; at least, until that level. The ultimate goal is to apprehend, not just manipulate. Complementary to our task, the reader will also develop and refine reading and writing skills. Due to the fact that we are addressing a mathematically illiterate audience, the contents should not reflect a traditional mathematical presentation which usually includes, among other characteristics: the usage of abstract definitions; the convention of accepting axioms and/or postulates without any discussion; a presupposed familiarity with an additional symbolic language, that allows to express equations; partial explanations that the user must complete by himself; and, most important, an unavoidable examination demanding the correct resolution of computational exercises to evaluate if the reader grasps the material. In brief, the magazine should be presented as the antithesis of almost any mathematical textbook. (Received July 16, 2012)

1086-VR-413 **Martin Concoyle*** (martinconcoyle@hotmail.com). *A new context in which to apply geometry to: math, quantum physics, and the solar system, etc.*

Quantum physics assumes the global and descends to the local (ie random particle-spectral measures). Is geometry a better vehicle to define the stability of quantum systems rather than function spaces?

Is the stable construct to be the very stable discrete hyperbolic shapes, in a many-dimensional context?

A geometrically stable and spectrally finite math construct, where, in adjacent dimensional levels, the bounding discrete hyperbolic and Euclidean shapes are defined, and then mixed as "metric-space states" in a Hermitian (or unitary) context, can provide a structure for stable properties.

Assume that math be consistent with (local) geometric-measures of stable shapes, which define finite spectral sets, contained in higher-dimensions. The stable shapes in the different dimensional levels are con-formally similar, and resonate with a finite geometric-spectral set contained in a high-dimension space.

A new interaction type consists of a combination of hyperbolic and Euclidean components, but when in an "energy-size range" the system can resonate with the spectra of the containing space, and thus it can change to a new stable, discrete shape. (Received August 30, 2012)

- 1086-VR-636 **Chris D Lynd*** (chris@math.uri.edu), RI. *Undergraduate Research Opportunities in Systems of Difference Equations.*

Systems of difference equations are frequently used in mathematical biology and computer science. In mathematics, Difference Equations is a relatively new area and is rich with open problems.

We will present a couple of open problems and give examples of how undergraduates can contribute to research in the area of systems of difference equations. With very little background, students can analyze the solutions of a system of difference equations by running computer simulations, discovering patterns, and making conjectures about the behavior of the solutions. With a background in real analysis and dynamical systems, students can prove some of those conjectures. (Received September 10, 2012)

- 1086-VR-667 **Sherrie Serros*** (serrossj@uwec.edu), 502 Hibbard Hall, Eau Claire, WI 54702, **Rebecca Ledocq** (rledocq.rebe@uwlax.edu), 1025 Cowley Hall, LaCrosse, WI 54601, and **Erick Hofacker** (erick.b.hofacker@uwrf.edu), 214C North Hall, River Falls, WI 54022. *Communicating Mathematically Through Podcasts.*

With funding provided through the UW System Growth Agenda Grant during the 2010-2011 school year, our team collaborated with 19 high school math teachers from 14 different schools on a project to increase the percentage of college freshman from Northwestern and West-central Wisconsin High Schools ready to enter credit-granting courses in mathematics in the UW-System.

The group began by examining the state math placement exam that is given to incoming students at UW campuses to identify the appropriate math course they should enroll in. We then moved on to identify mathematical threshold concepts which impeded student progress on moving through higher levels of mathematics when taking their high school mathematics courses.

In order to assist students with overcoming these thresholds, the group developed a database of mathematical podcasts that would be available for their students to view – separated over six different categories. The participants were trained to create the podcasts and critiqued them throughout the process. The complete collection is available at: <http://www.uwlax.edu/iiurl/pages/highschoolThresholdConceptsBasic.html>. Students have the option to leave feedback on the usefulness of each of the videos they view. (Received September 10, 2012)

- 1086-VR-718 **Bryan Nankervis*** (bn10@txstate.edu). *Effects of the Top Ten Percent Law in Texas.*

Bans on race-based affirmative action in public university admissions have limited efforts to diversify student enrollment. Some states have resorted to allowing students in the top decile(s) of their high school graduating class (or with a minimum high school GPA) automatic admission to public universities. As a consequence, academic standards at the more selective public institutions have dropped, Blacks and Hispanics remain greatly underrepresented, and otherwise highly qualified students have been forced to attend less selective schools. This paper will review the effects of the “Top Ten Percent Rule” on admissions in Texas since the Hopwood decision in 1996. Then it will look at representative school districts from Texas to explain why the flagship universities have struggled to diversify their campuses since the demise of affirmative action. (Received September 11, 2012)

- 1086-VR-739 **Brie A. Finegold*** (bfinegold@math.arizona.edu), University of Arizona Math Dept, 617 N. Santa Rita Ave, Tucson, AZ 85721. *What do you think of .999...? Inviting discussion with open ended questions.* Preliminary report.

We often urge elementary school mathematics teachers to focus on and analyze student thinking and support kids who invent their own algorithms. But often times upper division courses have a structure that allows instructors almost no access to their students’ thought process. We often walk into classes with strong expectations about what students will say and do. How can we relinquish some of these expectations while still creating a structure for students so that they do not feel like the instructor is “winging it”? I’ll provide some examples of techniques I’ve tried in my Real Analysis class as well as a course for future teachers. Student work will be provided to help give some insight into student thinking and progress. (Received September 11, 2012)

- 1086-VR-821 **Albert W Schueller*** (schuellaw@whitman.edu), 345 Boyer Avenue, Whitman College, Walla Walla, WA 99362. *Publishing math texts directly to the web—some fantastic open source tools.*

Historically, publishing mathematics on the web has been difficult. Most authors simply convert their documents to pdf and post the pdf files. In recent years, several nice tools have emerged that make publishing open source texts directly in html not only possible, but desirable. An argument will be presented that through the use of MathJax, embedded Sage, and JSXGraph, on-line texts become vastly more capable than simple pdf files. The efforts at conversion of David Guichard’s open source calculus text and Rob Beezer’s open source linear algebra

text from \TeX to html will be presented as examples. These free tools have the added benefit that they are platform independent in the sense that they will function on any computing device that has a Javascript-enabled browser (e.g. windows, mac, iPad etc). (Received September 13, 2012)

1086-VR-829 **Rosanna Iembo*** (rosannaiembo@libero.it), via Federico Cozzolino 18, Scafati, Salerno, Italy, **Irene Iaccarino**, via Interna Marina 19, 88900 Crotona, Italy, and **Michele Bernasconi**, Zurich, Switzerland. *Mathematics, Music and Biology: the "We" of Empathy*. January 2012, Boston, Joint Mathematics Meeting, Poetry Reading: Rosanna Iembo, mathematician, recited..... "Oh man, lover and dreamer! First you fall in love and then you wake from your dream, and search for a mathematician, who with the wisdom of old and philosopher shows the way. He will not tell you loved in vain, but you loved little because the other is you. And you precede I and together form we, the we of love, of life and peace". And Irene Iaccarino, violinist, played Massenet. But the best was yet to come! Summer 2012: the mathematician and the violinist met the biologist Michele Bernasconi and the "we" of math poetry and music, became the "we" of physiological-biological empathy. We want to present this as a work in progress. Rosanna and Irene have already talked about empathy at the JMM 2010 in San Francisco and at the JMM 2011 in New Orleans, describing the school of values of ancient times: the School of Pythagoras where mathematics, music and medicine melted, in search of the harmony of the human being. (Received September 23, 2012)

1086-VR-854 **Christopher Mandell*** (christophermandell@mail.adelphi.edu), 3218 4th Street, Oceanside, NY 11572. *Polynomial approximations of parameterized knots*. Preliminary report.

Consider the image of a curve $k(t) = \langle x(t), y(t), z(t) \rangle$. We discuss an algorithm for approximating the original parametric equations based on images taken orthogonal to each of the coordinate planes. We proceed by sampling points along the curve, and discuss how the accuracy is affected by increasing the sampling near points of increased curvature. (Received September 14, 2012)

1086-VR-862 **Zhanbo Yang*** (yang@uiwtx.edu), Department of Mathematical Sciences, CPO#311, University of the Incarnate Word, 4301, Broadway, San Antonio, TX 78209. *A report on the Mathematics S-STEM project at UIW*.

UIW received funding from NSF under the S-STEM program to support the Mathematics Scholars Program "Leading disadvantaged students to success" in 2008 (DUE-0803416). This project has a number of objectives that cover from recruitment, retention to career development. The first cohort of students under this program entered in the fall of 2009. Spring of 2013 is the final semester of this program.

We will report the both the quantitative and qualitative results of this project and share the lessons learned throughout this project. (Received September 14, 2012)

1086-VR-876 **Gerald M. Higdon*** (ghigdon@fitchburgstate.edu). *More Blips and Blops: Reciprocal Even and Reciprocal Odd Functions*. Preliminary report.

The saying "The Blip of the Blop Equals(?) the Blop of the Blip" has been used to represent the problem of interchanging the order of mathematical operations. An odd function, $f(-x) = -f(x)$, is, obviously, a "Blip of the Blop" in that it defines functions such that the function of the negation equals the negation of the function. This talk defines the concept of reciprocal even and reciprocal odd functions and presents several examples. Properties of such functions are studied along with how such functions relate to ordinary even and odd functions. Finally, the idea is considered in an abstract setting. (Received September 14, 2012)

1086-VR-1093 **Colm Mulcahy*** (colm@spelman.edu), Dept of Mathematics, Spelman College, 350 Spelman Lane, Atlanta, GA 30314. *Gilbreath Shuffle Variations*. Preliminary report.

The classic Gilbreath principle applies to a prearranged packet of cards, cycling a_0, a_1, \dots, a_n , over and over, let's say m times. If any number of cards—traditionally "about half of the packet" (roughly $\frac{mn}{2}$)—are dealt to a pile on the table, and the resulting two subpackets are then riffle shuffled together, it turns out that each set of n cards from the top down must consist of one each of a_0, a_1, \dots, a_n , in some order. What happens if the original packet is merely split in two, and these are riffle shuffled? Or if the original packet is split in three or more subpackets, all of these being riffle shuffled together? In a preliminary report of joint work with Ron Graham, we provide partial answers to these and related questions. (Received September 18, 2012)

- 1086-VR-1160 **Sandra G. Johnson*** (sgjohnson@stcloudstate.edu), **Melissa B. Hanzsek-Brill** (mbhanzsek@stcloudstate.edu) and **Sonja Goerdts** (sgoerdts@stcloudstate.edu). *Using Undergraduate Learning Assistants in Mathematics and Statistics.*

St. Cloud State University has implemented an Undergraduate Learning Assistant (ULA) program in its Mathematics and Statistics Department with the following goals in mind: •Create environments in our large-enrollment courses in which students can interact with one another, engage in collaborative problem solving, and articulate and defend their ideas. •Recruit and prepare talented mathematics and statistics majors and minors for careers in teaching or industry. •Engage mathematics and statistics faculty in the recruitment and preparation of majors and minors. •Improve the quality of mathematics and statistics education for all undergraduates. •Transform departmental culture to value research-based teaching as a legitimate endeavor for ourselves and for our students.

The authors will describe the programs instituted within the department, provide data, and discuss their own personal use of ULAs. The presentation will include a short video produced by a group of ULAs about student experiences in these classrooms. (Received September 19, 2012)

- 1086-VR-1195 **Martha H. Byrne*** (mbyrne@math.unm.edu). *Learning To Cooperate - one researcher's experiences building effective cooperative groups with students.* Preliminary report.

Well-designed cooperative work in classrooms can help students develop the skills necessary for successfully functioning on teams or committees post-graduation; however, getting students to work effectively in such groups provides many challenges. In a study exploring how students' proof skills and understanding of proof are affected by working in cooperative groups, the researcher employed varying strategies for fostering group efficacy. Comparisons of the efficacies of different strategies will be discussed. (Received September 19, 2012)

- 1086-VR-1239 **Donald A. Sokol*** (vsokol@sbcglobal.net), 11S047 Palisades Road, Burr Ridge, IL 60527. *The Many Faces of a Pythagorean Triple.*

The Many Faces of a Pythagorean Triple It is widely held in the mathematical world that given two non-negative integers x and y with x greater than y , x and y having opposite parity and being relatively prime will produce a Pythagorean triple in terms of a , b and c as follows: $a = x^2 - y^2$; $b = 2xy$; and $c = x^2 + y^2$, such that a , b , and c satisfy the Pythagorean relationship: $a^2 + b^2 = c^2$. What is not often discussed, and is the purpose of this paper, is the change in the identity of each triple (a, b, c) when either the sum or difference of the two integers (x, y) is substituted for either x or y in these equations. Not only does this allow all eight variations of an individual prime triple $(3, 4, 5)$ to be easily calculated, it enhances the ability to deal with negative numbers and it permits integers of equal parity to be addressed. The use of non-integer values through scaling, i.e. (13) can be 1.3 or 0.13 is also possible. Finally, the shift in the identity of each triple associated with each change in the equations bears a significant likeness to the characteristics of a code, suggesting one may be imbedded in this vast system of Pythagorean triples. This vast system may not be just for triangles anymore. (Received September 20, 2012)

- 1086-VR-1264 **Scott R. Kaschner*** (srkaschn@iupui.edu), 1138 Canterbury Square South, Indianapolis, IN 46260. *Dynamical Systems in the Sixth Grade Science Classroom.* Preliminary report.

This year I've been very fortunate to work with the GK-12 program, which places researchers from STEM fields into K-12 classrooms. My experience has been that often, very young students have an underlying intuition for mathematical concepts to which they have never formerly been exposed, and this program has given me the opportunity to explore that intuition using an inquiry-based approach.

This presentation will focus on the successes and failures I've had in presenting advanced mathematical concepts to a 6th grade science class. In particular, the students studied the exponential growth of error in a length measurement lab. Besides describing this lab and some of what both I and the students learned from it, I will discuss my plan and approach for future lessons this year. I intend to reiterate the exponential growth ideas in a population models lab, and this will lead into a lab on chaotic dynamics that explores "sensitive dependence on initial condition." (Received September 20, 2012)

- 1086-VR-1296 **Christina L. Arenas*** (sunshineincal@comcast.net), **Jose J. Covarrubias** and **Michael Hoffman**. *Can you have a Math Club at a small community college? Yes you can, but....*

This talk presents the creation and development of a Math club at a small community college in California. Cañada College has approximately 7,000 students with many of those being part-time. There is a strong MESA/STEM center. In the past two years the numbers of students in advanced math classes has doubled. There is a strong Engineering and Physics presence with student clubs such as Robotics, but until recently there was not a strong Math presence.

The Math Club at Cañada (MC²) began with a few students attending the JMM in Boston in 2012 and an energetic advisor. The Math Club had the biggest club event of the year and won awards from student government. That event was titled “Math Olympics.” Over sixty-five students attended not just from Math classes but also science classes. There was extra credit, free food, free t-shirts and lots of fun. Some things went quite well, other things did not. The question now is, will the club survive as some people leave and new people join? (Received September 20, 2012)

1086-VR-1403 **Paul A Loomis*** (ploomis@bloomu.edu), Bloomsburg University, 400 E Second St, Bloomsburg, PA 17815. *A Mathematical Tour in South America*. Preliminary report. During the first six months of 2012, I travelled in Peru, Bolivia, Argentina, and Chile. Along the way I visited ten universities, sitting in on classes, talking to students, professors, and administrators, and, at eight universities, giving a colloquium talk (in Spanish) in number theory. Here I will give an overview of my impressions of teaching and learning in South America. (Received September 21, 2012)

1086-VR-1440 **Cynthia Northrup*** (shepherc@uci.edu). *The Consistency Strength of $\text{Refl}(\omega_3, \omega, \omega_1)$* . First introduced by Paul Cohen to prove the independence of the Continuum Hypothesis and the Axiom of Choice, forcing is a technique used to extend a transitive model M by adjoining a new set G in order to obtain a larger transitive model $M[G]$ called a generic extension. Our choice of partial order determines what is true in the generic extension. Using Prikry forcing, we collapse the cofinality of a measurable cardinal κ to \aleph_0 while preserving all cardinals. With Raiden forcing we will collapse the cofinality of κ to an uncountable value. Our goal is to use these strategies to obtain a model M for which $M \models \text{Refl}(\omega_3, \omega, \omega_1)$ using an optimal large cardinal hypothesis. (Received September 22, 2012)

1086-VR-1666 **David Nacin*** (nacind@wpunj.edu), 300 Pompton Road, Wayne, NJ 07470. *Bit-player Calcudoku*. In the October 2010 entry of the blog Bit-player, a four-by-four Calcudoku over a set of complex numbers was posted with mention that the uniqueness of the solution had not yet been checked. We show uniqueness of the solution and classify all Calcudoku with similar conditions having unique solutions. (Received September 24, 2012)

1086-VR-2135 **Ira Waker** and **David S. Torain, II*** (david.torain@hamptonu.edu), Hampton University, Department of Mathematics, Hampton, VA 23668, and **Morris Morgan**. *An Eigenvalue Search Method using the Orr-Sommerfeld Equation for Shear Flow*. This work focuses on exploring the controllability of unmanned aerial vehicles’ (UAVs) flight formation, where the behavior of each vehicle is represented by a set of nonlinear state-space equations. The entire collection of vehicles comprises the system, where each individual UAV is a subsystem element. The lead vehicle is the driver while the remaining vehicles operate under the control of the driver. The overall effectiveness of the mission is predicated on the synchronization or coupling of the system among its constituent subsystems. One paramount question that is to be addressed is: what is the impact of the functional form of the state equations and controller structure on overall system stability? (Received September 24, 2012)

1086-VR-2141 **Larry Wayne Lewis*** (llewis@midcontinent.edu), 1217 S. 2nd Street, Louisville, KY 40203. *Does the Ability to Purchase a Week’s Worth of Groceries for less than One Dollar Influence the Chance that a Student will make an “Innumeracy Type” Statistical Error?* Some college students enrolled in applied statistical research courses appear to be unable to compare, with surety, the magnitude of decimal or percent numbers as evidenced by their hesitance or inability to quickly and correctly identify whether or not a calculated p-value is less than a specified significance level threshold, thereby producing an otherwise obvious “Innumeracy Type” error. The probability of an “Innumeracy Type” error (not to be confused with a Type I or Type II error) is possibly conditioned upon a student’s tendency to participate in a prevalent incorrect societal usage of certain decimal expressions. In an attempt to draw attention to a common improper use of the decimal point in the familiar context of American commerce and currency and its potential influence on students, the author proposed (in 2009) and conducted (in 2010) an action research study that employed a somewhat humorous PowerPoint presentation intervention that might improve the andragogical methodology for the teaching and learning of computationally challenged students. Results from this study will be shared. (Received September 24, 2012)

- 1086-VR-2377 **Ulrich Wilms*** (ulrich.wilms@cherokee.k12.ga.us). *Comparative Study of the National Math Curriculum with Curricula from Four Nations.*

The formation of the Common Core State Standards can be regarded as the predecessor of a national curriculum. This research addresses how the proposed national math curriculum compares to the math curricula of a sample of peer-nations (Singapore, Netherlands, Germany, and Japan) with high student achievement rates in math. The research indicated that the rigor and depth of the elementary math curriculum under the CCSS is in line with the elementary curricula of the peer-nations, yet the secondary math curriculum differs: whereas the CCSS expects all of the students to master a highly rigorous uniform secondary math curriculum, the peer nations of this research track their students according to aptitude and offer up to 12 different levels of math. In order to increase math achievement the presentation of math, using qualified math teachers in elementary school, may need improvement. Grading may have to be de-emphasized and replaced with detailed feedback, specific to individual work. A primary focus should be placed on appreciation and confidence. (Received September 25, 2012)

- 1086-VR-2491 **Paul Bialek*** (pbialek@tiu.edu), 2065 Half Day Rd, Deerfield, IL 60015. *What can I do with a Bachelor's degree in math? Five basic career fields for mathematics majors.*
Preliminary report.

Although people with a Bachelor's degree in mathematics can pursue a number of careers, these people tend to get jobs in five basic areas. We will look at these areas and give real-life examples of people who are in these fields. (Received September 25, 2012)

- 1086-VR-2533 **Hideo Nagahashi*** (hnagahashi@guam.uog.edu), Division of Mathematical Sciences, University of Guam, Mangilao, GU 96923. *Balanced Ternary and Quinary Numbers Magic Tricks.*

We present their variants via balanced ternary and quinary numbers, which have neat interpretations into playing cards. (Received September 25, 2012)

- 1086-VR-2584 **Minerva Cordero, James Epperson and Theresa Jorgensen*** (jorgensen@uta.edu). *Students communicating mathematics to a broader audience: using vertical connections in mathematics and school district partnerships as a vehicle.*

Finite geometries in 7th grade mathematics, ring theory in high school Algebra II, and modeling neurotransmitter flow in high school calculus – these are examples of lessons implemented by university mathematics students in middle and high school math classrooms. Through the University of Texas at Arlington NSF GK-12 project, we have developed a program in which mathematics graduate student fellows are paired with local school district math teachers to create school math lessons that integrate the fellows' university level mathematics into the school teachers' curriculum. The fellows must first communicate the essence of the mathematics they are studying to the schoolteachers, and then eventually, to the students in the teachers' classroom. The ultimate goal is to create mathematicians who can communicate their mathematics in a meaningful way to a broader audience.

We present an efficient framework for facilitating this collaboration. We will provide the targeted activities used to lead the pairs to develop the vertically connected math lessons integrating university and grade 7-12 level mathematics. Though this project has been conducted with graduate level students, the process highlighted here can be adapted to work with undergraduate mathematics students. (Received September 25, 2012)

- 1086-VR-2629 **Michael D Bice*** (mbice@csustan.edu), Mathematics Department, California State University, Stanislaus, 1 University Circle, Turlock, CA 95380, and **Heather A Coughlin** (hcoughlin@csustan.edu), Mathematics Department, California State University, Stanislaus, 1 University Circle, Turlock, CA 95380. *Teaching a Course in Mathematical Communication for Prospective High School Mathematics Teachers, Preliminary Report.*
Preliminary report.

At California State University, Stanislaus, the Mathematics Department offers a Subject Matter Preparation Program designed to train prospective high school mathematics teachers in content and in problem solving. In their senior year, students complete a capstone course entitled Senior Seminar in Mathematics. The primary focus of this class is to develop and improve mathematical communication in various forms and situations. Students write and present papers about problem solving techniques in the high school curriculum, and relate these techniques to the college-level mathematics studied in their undergraduate careers. Moreover, students provide critiques of journal articles found in mathematics education literature, and work in small groups to analyze and provide solutions to open-ended mathematical modeling problems. In this session, we will share our experiences with this course, discuss what has been accomplished and how our work has been influenced

by the 2012 MAA PREP Workshop on TEMPT, and present future directions we wish to pursue in developing students' mathematical communication skills. (Received September 25, 2012)

- 1086-VR-2661 **Karen Allen Keene** (karen.allenkeene@ncsu.edu), PO Box 7801, North Carolina State University, Raleigh, NC 27695, and **Alina Duca*** (anduca@ncsu.edu) and **Nadia Monrose**. *Integrating Calculus with Elementary Mathematics: Activities to Connect.*

Current reports call for the better preparation of science, technology, engineering, and mathematics (STEM)K-12 teachers as a way to create a STEM-literate population who can address many of the nation's problems. Conceiving of well-prepared, STEM focused elementary teachers is one way to deal with the on-going demand to increase the STEM pipeline. The presenters will describe a course that has been developed to integrate the concepts of calculus, including derivative, limit, and integral with some of the primary ideas that future elementary teachers need to know to teach their future students. After giving an overview of the two semester course, the presenters will discuss two class activities, one about limit, and one about derivative. The presenters will show work from the students who have been in the second pilot of the course and discuss the importance of making connections between different fields of mathematics and developing deep understanding for the future teachers of our children. (Received September 25, 2012)

- 1086-VR-2723 **Jean W. Richard*** (jrichard@bmcc.cuny.edu), 199 Chambers Street, New York, NY 10007, and **Abdramane Serme** (aserme@bmcc.cuny.edu), 199 Chambers Street, New York, NY 10007. *The Support of the International Mathematics Community to Hua Loo-keng.*

This presentation explores the support that the self-taught Chinese mathematician Hua Loo-keng (1910 -1985) received from the international mathematics community. This presentation seeks to demonstrate how several mathematicians and scientists offered genuine support to Hua Loo-keng during several stages of his life. At Tsing Hua University in 1934, he was discovered by Norbert Weiner who arranged for him to study with Hardy at Cambridge University. Later it was Hermann Weyl who initiated support to Hua Loo-keng by accepting to edit his mathematical research papers and submitting them for publication in American mathematics journals. Thereafter, Hermann Weyl insisted that Hua Loo-keng travel to the Institute for Advanced Study at Princeton. Hua Loo-keng will be doing research alongside scientists like Albert Einstein, Robert Oppenheimer, and Marston Morse. At the Institute he collaborated with two mathematicians Harry Schultz Vandiver, another self-taught mathematician and Irving Reiner. During the "Open-door" policy in the People's Republic of China and the last year of Hua Loo-keng's life, several mathematicians will be there in 1980 to welcome him at several universities in the United States. (Received September 25, 2012)

- 1086-VR-2763 **Amber Rosin*** (arrosin@csupomona.edu), 3801 West Temple Ave., Pomona, CA 91768. *Equal Labelings for pq -sided dice and the Inevitability of Stupid Dice.*

Given a pair of standard six-sided dice one can get any of the sums $2, 3, \dots, 12$. But these sums are not all equally likely to occur. It is well known – and easy to show – that it is impossible to relabel a pair of dice in such a way that the sums 2 through 12 become equally likely. However, it is possible to relabel seven dice in such a way that the standard sums of $7, 8, 9, \dots, 42$ are all equally likely. We will characterize the numbers m for which m pq -sided dice have an equal labeling (where p and q are distinct primes). We will also find that such relabelings require the use of some very stupid dice. (Received September 25, 2012)

- 1086-VR-2917 **Abdramane Serme*** (aserme@bmcc.cuny.edu), 199 Chambers Street, New York, NY 10007. *Students Mentoring (by faculty) Programs in a Community College.*

Many have thought that students in communality colleges are not able to conduct research in mathematics. The logic behind the thinking is the fact that many students come to community colleges immature, unprepared (Brock, 2010) for college level classes therefore cannot be productive in student research programs. During this talk, we show by providing some of the student research projects, that students in community colleges are ready and are doing valuable research projects. They actively participate in the research programs. Even if some faculty members see student research programs as a burden (Mervis, 2001) given the trade off in their own teaching load and scholarly work, students in majority are very enthusiastic and appreciative of the research programs according to Mervis. The presentation also aims to show that one way to solve the shortage of students trained in mathematics, to fight plagiarism, as well as improving the U.S. ranking among industrialized counties in mathematics and science is to start strong student research programs at community college level. (Received September 26, 2012)

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