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   * Indicates who will present the paper at the meeting.

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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
1067	January 6–9, 2011	New Orleans, LA	EXPIRED	Vol 32, No. 1
1068	March 12–13, 2011	Statesboro, GA	January 20	Vol 32, No. 2
1069	March 18–20, 2011	Iowa City, IA	January 25	Vol 32, No. 2
1070	April 9–10, 2011	Worcester, MA	February 15	Vol 32, No. 3
1071	April 30–May 1, 2011	Las Vegas, NV	March 8	Vol 32, No. 3
1072	September 10–11, 2011	Ithaca, NY	July 19	Vol 32, No. 4
1073	September 24–25, 2011	Winston-Salem, NC	August 2	Vol 32, No. 4
1074	October 14–16, 2011	Lincoln, NE	August 23	Vol 32, No. 4
1075	October 22–23, 2011	Salt Lake City, UT	August 30	Vol 32, No. 4
1076	November 29–December 3, 2011	Port Elizabeth, South Africa	TBA	None

NEW ORLEANS, LA, January 6–9, 2011

Abstracts of the 1067th Meeting.

00 ► General

1067-00-37 **Robert J. Lang***, Robert J. Lang Origami, Alamo, CA. *From flapping birds to space telescopes: The mathematics of origami.*

The last decade of this past century has been witness to a revolution in the development and application of mathematical techniques to origami, the centuries-old Japanese art of paper-folding. The techniques used in mathematical origami design range from the abstruse to the highly approachable. In this talk, I will describe how geometric concepts led to the solution of a broad class of origami folding problems - specifically, the problem of efficiently folding a shape with an arbitrary number and arrangement of flaps, and along the way, enabled origami designs of mind-blowing complexity and realism, some of which you'll see, too. As often happens in mathematics, theory originally developed for its own sake has led to some surprising practical applications. The algorithms and theorems of origami design have shed light on long-standing mathematical questions and have solved practical engineering problems. I will discuss examples of how origami has enabled safer airbags, Brobdingnagian space telescopes, and more. (Received June 10, 2010)

1067-00-72 **Rim Gouia*** (`rim.gouia@mavs.uta.edu`). *Inversion of the circular Radon transform from partial data.*

The circular Radon transform Rf puts into correspondence to a given function f its integrals along circular trajectories. The need for such a transform arises in several contemporary problems of medical imaging, synthetic aperture radar and non destructive testing.

The major problems related to the circular Radon transform are the existence and uniqueness of its inversion, inversion formulas and the range description of the transform. In the case, when the circular Radon transform Rf is known for circles of all possible radii, there are well developed theories now addressing most of the questions mentioned above. However, many of these questions are still open when Rf is available only a part of all possible radii.

The aim of my presentation is to discuss some new results about existence and uniqueness of the inversion of the circular Radon transform from partial data and briefly describe the mathematical challenges of this inversion. (Received July 11, 2010)

1067-00-143 **Marilyn Manee Smith*** (smith7mm@cmich.edu), 6290 N Vandecar rd, Farwell, MI 48622, and **Megan Elizabeth Haske** and **Darren Everett Sowards**. *Optimal Ranges for ECG Noise Removal by Using Wavelets.*

An electrocardiogram, or ECG, shows the electrical activity in the heart and can be used to detect abnormalities. Wavelets are a good analysis tool for denoising non-stationary signals like ECGs. The goal of this study is to determine the optimal wavelet, order, level, and threshold for denoising an ECG while smoothing out and maintaining the integrity of the original signal. The wavelets used are: Daubechies, Biorthogonal Spline, Coiflet, and Symlet. Soft thresholding is used with the following thresholdings: Rigorous Sure, Heuristic Sure, Universal, and Minimax. The signal-to-noise ratio is used in combination with the percentage root mean square difference to determine the optimal conditions for wavelet denoising. (Received July 27, 2010)

1067-00-386 **Robert Douglas McGuigan*** (rmcmoose@sbcglobal.net), 6150 Ellerbrook Way, San Jose, CA 95123. *Lower Bounds for the Ropelength of Reduced Conformations.*

This paper generalizes the results of Sadjadi (2007) and Alley (2009) by providing an algorithm to find a lower bound for the ropelength of any conformation which admits a reduced diagram. This lower bound is found by changing this problem of geometry into one of linear programming, which is then solved by the simplex algorithm. (Received August 31, 2010)

1067-00-465 **Shlomo Gelaki** and **Deepak Naidu*** (dnaidu@math.tamu.edu), Department of Mathematics, College Station, TX 77843, and **Dmitri Nikshych**. *Drinfeld centers of graded fusion categories.*

The Drinfeld Center is an important construction in the theory of tensor categories. It is a way of producing a braided tensor category from a (not necessarily braided) tensor category. In this talk, I will describe how the structure of the Drinfeld center of a fusion category can be understood in terms of a smaller and more transparent category. As an application, I will give a criterion for a fusion category to be group-theoretical and apply it to the Tambara-Yamagami categories to produce non group-theoretical semisimple Hopf algebras, extending a construction of Nikshych. (Received September 05, 2010)

1067-00-1056 **Rachel Wells Hall*** (rhall@sju.edu), Department of Mathematics, Saint Joseph's University, Philadelphia, 19131. *Eine Kleine Mathmusik: Six Mathematical Compositions for Bridges Pécs 2010.*

In this talk, I consider six mathematically inspired musical compositions written for the 2010 Bridges Conference in Pécs, Hungary. Adrian Childs' *campanologicalplainbobmobile,* for bell choir, explores the connection between permutation groups and the ancient English art of change ringing. Ferdando Benadon's *Clave Sin* for jazz quartet employs similar rhythmic patterns played in different time signatures, creating tension between rhythms that are almost, but not quite, the same. Clifton Callender's *Hungarian Jazz*, for jazz quartet, uses a "Risset rhythm" to create the effect of continuous acceleration—a musical equivalent of Escher's *Print Gallery*. By embedding the first 768 digits of π in his three *Steganographic Etudes*, Noam Elkies demonstrates the limits of musical coherence. Giovanni Albini's *Two Studies* exhibit two types of symmetry: abstract, harmonic symmetry and the physical symmetry of hands on the piano. Finally, Dmitri Tymoczko's *Cyberpunk Study no. 1: Waltzing with Wolfgang while Conlon Looks On*, inspired by a large statistical study of harmony in Mozart, combines algorithmic composition with a more improvisational, organic approach. I will discuss the math explored by each composer and play short recordings. (Received September 22, 2010)

1067-00-1299 **Andrew Lazowski*** (lazowskia@sacredheart.edu), 5151 Park Ave., Fairfield, CT 06825. *Porosity and limit sets.*

In this talk we will discuss the porosity of limit sets of Kleinian groups. In particular, porosity provides information about its Hausdorff dimension. Some recent results will be given. (Received September 20, 2010)

1067-00-1330 **Quan T Tran*** (qtran@ou.edu), 3831 NW 10, Oklahoma City, OK 73107. *Snowflake Groups with Super-Exponential 2-Dimensional Dehn Functions.*

In their paper *Super-Exponential 2-Dimensional Dehn Functions*, J. Barnard, N. Brady and P. Dani produced groups of type $\mathcal{F}_3$ with 2-dimensional Dehn functions $\delta^2(x) = exp^m(x)$, where m is a natural number. And N. Brady, M. Bridson, M. Forester and K. Shankar produced in their paper *Snowflake Groups, Perron-Frobenius Eigenvalues, and Isoperimetric Spectra* groups of type $\mathcal{F}_{n+1}$ whose n-dimensional Dehn functions are $\delta^n(x) = x^s$ for any $s \in \mathbb{Q} \cap [2, \infty)$. We will combine these two ideas to produce groups of type $\mathcal{F}_3$ whose 2-dimensional Dehn functions are $\delta^2(x) = exp^m(x^s)$. (Received September 20, 2010)

1067-00-1397 **Theodore Kolokolnikov*** (tkolokol@mathstat.dal.ca), Dalhousie University, Halifax, NS B3H 3J5, Canada. *Explicit results for the swarm aggregation model in any dimension.*

In a recent work by Bernoff and Topaz, an exact solution for the swarm model involving a Morse force was derived in one dimension. On the other hand, there are no known (non-trivial) examples of exact solutions to the swarm model in two or higher dimensions. We derive a new such solution for a certain class of attractive-repulsive forces. We also study its stability in one and two dimensions.

Joint work with Razvan Fetecau. (Received September 20, 2010)

1067-00-1440 **Antoine V Elabdouni*** (antoine_elabdouni@berkeley.edu). *Linear and Nonlinear Inverse Problems.* Preliminary report.

We consider both Linear and Nonlinear Inverse Problems, in which we must reconstruct a parameter from an observed data set. The linear problem is that of reconstructing a clear image, given a blurred (convoluted) version of it. Different methods are explored for solving linear rank-deficient systems (as is the case in this example), namely Krylov Iteration and Tikhonov Regularization with which we eventually "solve" the problem. The nonlinear problem is that of reconstructing the heat conductivity of a cooling fin, modeled by a 2-dimensional steady-state equation with Robin boundary conditions. The Metropolis Hastings Markov Chain Monte Carlo algorithm is studied and implemented, as well as the notion of priors. Different methods for generating the next guess in the algorithm are developed and the results of these methods discussed. This work was supported in part by the National Science Foundation REU and Department of Defense ASSURE Program held at George Mason University (Summer 2010). (Received September 21, 2010)

1067-00-1610 **Suman Sanyal*** (sanyal@marshall.edu), Department of Mathematics, One John Marshall Drive, Huntington, WV 25755. *Mean Square Stability of Ito-Volterra Dynamic Equation.*

This paper presents a sufficient condition for the mean square stability of Itô–Volterra dynamic equation on isolated time scales. (Received September 21, 2010)

1067-00-1673 **Ximena Catepillan*** (ximena.catepillan@millersville.edu), Mathematics Department, Millersville University, PO Box 1002, Millersville, PA 17551. *A First Year Experience Seminar.*

In 2006 I developed the Freshman Experience Seminar "Culture, Science, and Mathematics in the Pre-Columbian Americas" for the School of Science and Mathematics at Millersville University of Pennsylvania. Seminar Description: An introduction to the study of the Pre-Columbian Americas, part of the broad interdisciplinary field of Native American Studies. The emphasis will be on the role that science and mathematics played in the culture of these indigenous groups (including the Aztec, Inca, Maya and other Native American groups). The course will explore the Pre-Columbian world through the eyes of our ancestors, as well as through our classmates. Special attention to the science of archaeoastronomy and mathematics in which all of the great cultures of antiquity have left a mark. In this talk, the syllabus will be discussed as well as classroom activities used in the seminar. (Received September 21, 2010)

1067-00-1676 **Emily J Forney*** (eforney@clemson.edu), 608 Berkeley Place Circle, Clemson, SC 29631. *Optimization of an Antenna Structure for a Photovoltaic Nanodevice.*

Finding a cleaner, renewable energy fuel source is increasingly important. One possible solution to this problem is to build a photovoltaic nanodevice that utilizes the reaction center from Rhodobacter Sphaeroids. We developed a new methodology that allows the optimization of a structure and design of a wide range of photovoltaic nanodevices. In this research, the methodology is used to test a particular design with metal nanospheres sandwiched in between two nonmetal transparent electrodes. This design takes advantage of localized plasmonic effects. We have found the optimal structure that allows a maximum amount of light in the charge separation region for a fixed light wavelength. This work has been completed as a part of the 2010 REU Program at George Mason University funded by the NSF-REU and DOD-ASSURE Programs. (Received September 21, 2010)

1067-00-1687 **John R Corring*** (johncorring@gmail.com), 103 Ross Blvd, Apartment B12, Hattiesburg, MS 39401, **Helene Duke** (hduke@friars.providence.edu), 503 River Road, Wilmington, DE 19809, **Arundhati Bagchi Misra** (ab659@msstate.edu), P.O. Box MA, Mississippi State, MS 39762, and **Hyeona Lim** (hlim@math.msstate.edu), P.O. Box MA, Mississippi State, MS 39762. *Edge-Enhancing Speckle Denoising for Ultrasound Images.*

Ultrasound images contain pervasive granularity which interferes with human analysis and automated processing of the images. Presently, professionals tolerate this granularity and are expected to work around it. As the medical community moves closer and closer to a digital standard of operation, fast and effective ultrasound denoising must account for the disparity in image quality between ultrasound and more robust, though more expensive, imaging techniques. Towards removing this granularity we develop an edge-enhancing denoising model which treats the granules in ultrasound images as speckle noise. Our partial differential equation based model, derived from a minimizing functional constrained by a new noise equation, is more efficient in removing speckle noise in ultrasound images than the existing models. A corresponding explicit time-stepping scheme from a non-standard finite difference discretization is proven to be stable. We also discuss and evaluate some parameterization techniques. Our scheme compares favorably with existing techniques, providing smooth results very quickly. Images clarified by our scheme are shown to be much more suitable for further automated processing tasks. (Received September 21, 2010)

1067-00-1866 **Irina Mitrea*** (imitrea@ima.umn.edu), Inst. for Mathematics and its Applications, University of Minnesota, 207 Church St. S.E., 411 Lind Hall, Minneapolis, MN 55455. *Topics in quasi-metric geometry.*

The purpose of this talk is to discuss how a number of results of fundamental significance in metric geometry can be extended to the more general setting in which the role of the distance is played by a function satisfying a quasi-ultra metric condition.

I will be emphasizing two topics - one is the nature and structure of Holder functions in this setting and the other one is an adaptation of the Gromov-Hausdorff distance to the framework of quasi-metric spaces. (Received September 22, 2010)

1067-00-1870 **Irina Mitrea*** (imitrea@ima.umn.edu), Inst. for Mathematics and its Applications, University of Minnesota, 207 Church St. S.E., 411 Lind Hall, Minneapolis, MN 55455. *An optimal metrization theorem for topological groupoids.*

Metrization theorems (i.e. the question whether a certain topology is induced by a metric) play a basic role in many areas of mathematics including topology, functional analysis, analysis on spaces of homogeneous type, partial differential equations, etc.

In this talk I will discuss a sharp general metrization theorem in the setting of abstract groupoids (groupoids have been introduced by Brand in the 1920's as ageneralization of groups which also include arbitrary sets). This theorem contains as particular cases several basic metrization results such as Alexandroff-Urysohn metrization theorem in Topology, the Aoki-Rolewicz metrization theorem in Functional Analysis and the Macias-Segovia metrization theorem in Harmonic Analysis. (Received September 22, 2010)

1067-00-1961 **Robert Wannamaker*** (rwannama@calarts.edu), The Herb Alpert School of Music, California Institute of the Arts, 24700 McBean Parkway, Valencia, CA 91355. *The Rational Number System as a Generator of Musical Form.*

The structures of multilayered divisive polyrhythms are modeled in ways that elucidate their perceptible features and relate them to properties of the rational number system. Frequency ratios ordered by size are presented as a harmonic manifestation of similar structures. Illustrative examples are drawn from the music of American composer James Tenney (1934-2006). (Received September 22, 2010)

1067-00-1966 **Dmitri Tymoczko*** (dmitri@princeton.edu), 310 Woolworth Center, Princeton, NJ 08544. *Mathematical Concepts in Musical Composition.*

In my talk I will consider some ways in which recent music-theoretical developments can be applied compositionally. I begin by reviewing some general questions that have been the focus of intensive theoretical work: What makes a good scale? How can modulation be modeled in the seven-dimensional orbifold representing seven-note chords? What are voice leadings and how can they be categorized? Under what circumstances can harmony and voice leading be combined? I then describe some broad strategies for musical organization, including two popular twentieth-century techniques that I call "scale first" and "chord first" composition. Finally, I present some musical pieces that exploit this new body of theoretical knowledge, including a piece of electronic music whose harmonies are generated by a second-order Markov model derived from Mozart's piano sonatas. (Received September 22, 2010)

1067-00-1969 **Clifton Callender*** (clifton.callender@fsu.edu), College of Music, Florida State University, Tallahassee, FL 32306. *Spira mirabilis, for player piano.*

The focus of this presentation will be ongoing compositional applications and extensions of self-replicating melodies, pioneered by Tom Johnson, and Risset rhythms, rhythmic analogues of Shepard tones, originally created and explored by Jean-Claude Risset. Mapping logarithmic spirals (which Jacob Bernoulli called *Spira mirabilis*) to both the time and pitch (in particular, the circle-of-fifths) domains yields continually accelerating self-replicating lines that are globally chromatic yet continuously modulate through closely-related diatonic collections. (Received September 22, 2010)

1067-00-1972 **Joceline Lega*** (lega@math.arizona.edu), Department of Mathematics, 617 N. Santa Rita, Tucson, AZ 85721. *The Institute for Mathematics and Education.*

The Institute for Mathematics and Education (IM&E), founded in 2006 at the University of Arizona (UA), brings together mathematicians, educators, and policy makers to address critical concerns related to the mathematical education of K-16 students.

I will describe a variety of programs, events, and activities supported by the IM&E, including outreach efforts to local school districts (through our Math and Teachers' Circles), professional development of K-8 teachers (Intel Math program), workshops for mathematicians and educators, outreach to UA science faculty (through our BioMath Circles), and partnerships between graduate students and K-12 teachers.

The Institute's programs are supported by the National Science Foundation, The University of Arizona, the Intel Foundation, the Howard Hughes Medical Institute, the Brookhill Foundation, as well as private donors. (Received September 22, 2010)

1067-00-2084 **Thomas Jaeger*** (jaeger@math.msu.edu). *Khovanov-Rozansky Homology and Conway Mutation.*

We show that the reduced $\mathbf{sl}_n$-homology defined by Khovanov and Rozansky is invariant under orientation and component preserving mutation when n is odd. (Received September 22, 2010)

1067-00-2244 **Juan H Hinojosa**, 5201 University Boulevard, Laredo, TX 78041-1900, **Firooz Khosraviyani*** (FiroozKh@TAMIU.edu), 5201 University Boulevard, Laredo, TX 78041-1900, **Rohitha Goonatilake** (harag@tamiu.edu), 5201 University Boulevard, Laredo, TX 78041-1900, and **Rafic A Bachnak**, 5201 University Boulevard, Laredo, TX 78041-1900. *Synopsis of a Program Promoting Mathematics and Science Studies among Hispanics and Other Minorities.* Preliminary report.

At every level of State and Federal governments efforts are underway to improve undergraduate student retention rates among Hispanics and other minority students pursuing mathematics and science degree programs in academic institutions. This article describes one such effort being undertaken at Texas A&M International University (TAMIU), in Laredo, Texas that focuses on increasing retention and graduation rates primarily by forming student cohorts , and by providing enrichment, advising, and mentoring as part of the STEM Recruitment, Retention, and Graduation (STEM-RRG) project, funded by the US Department of Education. In addition to discussing this unique endeavor in improving retention and graduation rates, the article also describes how TAMIU was able to formulate this program through a carefully planned format and activities which were conducted in two-week-long sessions and some monthly follow-up sessions. (Received September 22, 2010)

1067-00-2328 **Sandra Jeannette Varela*** (sandyarela@yahoo.com), 587 Cappella Dr., Diamond Springs, CA 95619. *Phase Diagram Calculation via Constrained Optimization.*

Material scientists and engineers rely heavily on the accuracy of phase diagrams in an effort to understand how materials act under given circumstances. We introduce an approach differing from other previously known methods of phase diagram calculation in that we are solving it directly as a constrained optimization problem, using sequential quadratic programming technique implemented in the SNOPT solver of the AMPL package. The method is presented here for the ternary Ca-Li-Na system, though it can be used on any multicomponent multi-phase system, including multiple sublattice case. Comparisons with the commonly used phase diagram calculation software Thermo-Calc are provided.

This work has been completed as a part of the 2010 REU Program at George Mason University funded by the NSF-REU and DOD-ASSURE Programs. (Received September 22, 2010)

1067-00-2420 **Bacim Alali*** (alali@math.utah.edu), 155 S 1400 E ROOM 233, Salt Lake City, UT 84112, and **Daniel Onofrei** (onofrei@math.utah.edu), 155 S 1400 E ROOM 233, Salt Lake City, UT 84112. *Coordinate transformations of two scale convergent sequences.*

We discuss how coordinate transformations, such as translations, rotations, and scalings, affect two scale convergence. We show, for example, that a two scale convergent sequence is no longer two scale convergent once translated, except for "trivial" translations. (Received September 23, 2010)

01 ► History and biography

1067-01-26 **Maritza M. Branker*** (mbranker@niagara.edu), Department of Mathematics, Niagara University, Lewiston, NY 14109, and **Joseph J. Little**. *Neither Positive nor Negative nor yet Null numbers: Analogy in William Rowan Hamilton's Argument for imaginary numbers.*

Studies of analogy in technical discourse have made important strides in the thirty years since George Lakoff and Mark Johnson ushered in the cognitive linguistic turn. Scientific analogy has been discussed, illuminating both interpersonal and intrapersonal faces of its epistemic functioning but no one has considered how analogy functions in research level mathematics.

We analyze the role of analogy in William Rowan Hamilton's 1837 work, "Theory of conjugate functions, or algebraic couples; with a preliminary and elementary essay on algebra as the science of pure time". Hamilton's theory was developed in order to place the concept of complex numbers on a secure algebraic footing, after less than successful attempts by others to legitimize them by introducing geometrical interpretations. Hamilton's elegant solution was to reinterpret the existing real number system in a purely algebraic manner to allow a natural and rigorous extension which would encompass, but not be limited to complex numbers.

We make the argument that in this seminal work analogy served substantively in the rigorous work of mathematical activity itself, positioned not alongside mathematics but underlying it. (Received May 31, 2010)

1067-01-132 **Jiang-Ping Jeff Chen*** (jjchen@stcloudstate.edu), ECC 226, Department of Mathematics, 720 4th Ave. South, St. Cloud, MN 56301. *Trigonometric Tables in China.*

Before the Jesuits arrived in China in late 1500s, Chinese mathematics did not use trigonometric methods. Trigonometric tables were among the powerful computation tools the Jesuits brought to China. The Jesuits used them to simplify computations in astronomy while Chinese astronomers, before the Jesuits, employed interpolations to meet the same needs. In a way, interpolation methods could be construed as Chinese equivalent to the tables. Although the Jesuits provided the basic principles of making the tables, there were technical details left unexplained, which made reconstruction utterly impossible. Chinese scholars in the 17th century, motivated to constructed 'Chinese' tables, attempted to bridge the gap with various approaches. As these scholars were not Astronomic Bureau officials, their efforts to reconstruct the tables were for their own intellectual pursuit. In the 19th century, after the publication of several treatises which utilized power-series like approach to calculate the values of trigonometric lines from the length of the arc and vice versa, the trigonometric tables were then replaced by the utilization of these computational algorithms. The return to algorithms, though different ones, mirrored Chinese scholars' desire to follow the traditional practice. (Received July 26, 2010)

1067-01-400 **Günther Oestmann*** (oestmann@nord-com.net), Gandersheimer Str. 20, 28215 Bremen, Germany. *Delayed Progress in Navigation: The Introduction of Line of Position Navigation in the 19th Century.*

In 1843 the American sea captain Thomas H. Sumner published a small book under the title "A New and Accurate Method of Finding a Ship's Position at Sea by Projection on Mercator's Chart", which was the result of an accidental observation he had made six years before. The discovery of the line of position by celestial observation was rightly called "the commencement of a new era in practical navigation" by Matthew Fontaine Maury and forms the basis of celestial navigation until present time. Although Sumner's method was adopted immediately in the U.S. Navy and accepted readily in the Royal Navy also, its reception took a considerable longer period of time in other countries. In my paper a survey of this process shall be given. (Received September 01, 2010)

1067-01-521 **Adrian Rice*** (arice4@rmc.edu), Department of Mathematics, Randolph-Macon College, Ashland, VA 23005. *"Splendidly isolated"? Some reflections on the transnationality of 19th-century British mathematics.* Preliminary report.

The phrase "splendid isolation" is often used to describe late 19th-century British foreign policy, which was characterized by a self-imposed aloofness from the affairs of mainland Europe. But could the same words be used to describe much of 19th-century British mathematics? After all, mathematics in 19th-century Britain was typified by a certain insularity with regard to European mathematical developments, and the character and style of British mathematics differed considerably from that produced on the continent. Nevertheless, at the same time many British mathematicians were in touch with both European mathematical developments and European mathematicians, and several of the notable contributions made by British mathematicians during this period were well known on the continent. So was mathematical communication really impeded by the English Channel? To what extent did 19th-century British mathematical developments transcend national boundaries?

In this talk, we will examine the extent of British mathematical "isolation" during the 19th century and attempt to reach some estimation of how "splendid" this status really was. (Received September 08, 2010)

1067-01-567 **Mary W. Gray*** (mgray@american.edu), Department of mathematics and statistics, American University, 4400 Massachusetts Avenue NW, Washington, DC 20016-8050. *Life in the Trenches with Alice–The Early Years.*

Let's fight City Hall—in our case, the mathematical establishment. For many years Alice Schafer knew and I knew, that women could do mathematics, and that given the chance, we could prove it. In the early years, it took some courage, and lots of persistence, to see that as many women as possible got that chance. Alice's short stature, Southern accent and Southern grace, led many a mathematician, male and even sometimes female, to underestimate her persistence and her commitment. Madeline Albright is credited with saying that there is a special place in hell for women who do not help other women. That is a place ever unknown to Alice. The successes were many, the struggles eternal. (Received September 09, 2010)

1067-01-613 **James J. Tattersall*** (tat@providence.edu), Department of Mathematics, Providence College, Providence, RI 02918, and **Shawnee L. McMurran**. *Mary Cartwright and G.H. Hardy's 1928 Oxford Seminar.*

In the fall of 1918, Mary Cartwright matriculated at St. Hugh's, Oxford. Four years later she achieved a First Class in mathematics on the Oxford Finals. She was the first women to achieve that distinction. She taught at the Alice Oxley School and later at the Wycombe Abbey School before returning to Oxford in 1928 where she attended Hardy's graduate seminar. Cartwright received her D.Phil. degree from Oxford in 1930 under the supervision of Hardy and E.C. Titchmarsh. We focus on her Oxford undergraduate education and her impressions of and contributions to Hardy's seminar. (Received September 11, 2010)

1067-01-623 **Lawrence A. D'Antonio*** (ldant@ramapo.edu), 24 Meadoway, Dobbs Ferry, NY 10522. *Gauss on the Composition of Quadratic Forms: Group Theory without Groups.* Preliminary report.

The theory of quadratic forms as presented by Gauss in his Disquisitiones Arithmeticae is a stunning achievement. One marvels at the depth and breadth of the invention of Gauss. In this talk we will focus on one aspect of that work, his definition of the composition of quadratic forms. This is not the familiar composition of functions; rather it is an abstract binary operation that is specifically defined for quadratic forms. Gauss shows that this operation obeys the associative law (without explicitly using that name). So has Gauss defined a group operation for quadratic forms? No, for as Gauss himself states, the composition is only defined under certain conditions. But has Gauss taken the first steps towards abstraction in algebra? We will look at this question in the context of the work of his predecessors, Euler and Lagrange. (Received September 11, 2010)

1067-01-861 **Jemma Lorenat*** (jlorenat@sfu.ca). *How "Kroneckerian" became an adjective.*

This paper will present and compare several varied responses to Leopold Kronecker's philosophy of mathematics, beginning with the indignation and resistance of the Berlin School lead by his colleague Karl Weierstrass from the 1870s and ending with Kronecker's modest resurgence in recent years alongside the rise of algorithmic computation. During the intervening century, biographers, former students, philosophers, and historians of mathematics helped to fashion the Kroneckerian myth. These opinions and allegations were often based on contextual factors well beyond his original philosophy or mathematics. Kronecker's evolving reception reflects the shifting trends of mathematics since the late nineteenth century. (Received September 15, 2010)

1067-01-918 **M. Moazzam*** (mxmoazzam@salisbury.edu), Salisbury University, 1101 Camden Ave., Dept of Math & Computer Science, Salisbury, MD 21804-1845. *"Mathematician's Trio"*. Preliminary report.

The purpose of this talk is to present three Persian brother-mathematicians/scholars (Bono Musa) who made significant contributions to mathematics, astronomy, and mechanics as early as the 9th century. Participants will gain not only a cross-cultural appreciation of the dedication and sacrificial undertakings of these scholars, but also a sense of the breadth of knowledge of these learned persons across several academic disciplines. (Received September 16, 2010)

1067-01-941 **Robert E. Bradley*** (bradley@adelphi.edu), Adelphi University - Dept. of Mathematics, 1 South Ave., Garden City, NY 11530. *The Binomial Theorem from Newton to Cauchy.*

Newton discovered the General Binomial Theorem in the 1660s. Although he could demonstrate that it was true in many special cases, he did not initially have a general proof. Taylor's theorem provides a general proof that is within the grasp of a modern undergraduate, but an elementary proof (one not requiring the differential calculus) was considered desirable. Such a proof was finally given by Euler in 1775. It became widely known in a somewhat more polished form thanks to Cauchy's *Cours d'analyse* (1821).

We investigate the historical reasons for preferring elementary proofs over calculus-based ones and present the details of the Euler-Cauchy proof. (Received September 16, 2010)

1067-01-1012 **Menolly Lysne*** (menolly.lysne@utoronto.ca), Room 316, Victoria College, 91 Charles Street West, Toronto, ON M5S 1K7, Canada. *Advertising and Patronage in Laplace's Early Writing.* Preliminary report.

Jean le Rond d'Alembert (1717-1783) acted as patron to Pierre Simon de Laplace (1749-1827) from Laplace's early days in Paris in 1769. While the story of Laplace's introductions to d'Alembert has areas of mystery around it, we will concentrate on how Laplace's relationship with d'Alembert can be seen in Laplace's early published work. D'Alembert was able to aid Laplace in finding employments at the École Militaire and later in Laplace's successful election to the Paris Académie des Sciences. Laplace showed his gratitude to d'Alembert by citing and praising his patron's work. While Laplace frequently cited the more senior scientist, he rarely used d'Alembert's results. Lapalce may have felt it necessary to laud the work of the man who had helped him, but, as we will see, when Laplace failed to adequately cite d'Alembert, d'Alembert found ways of ensuring that his contributions were not ignored. (Received September 17, 2010)

1067-01-1017 **Niccolò Guicciardini*** (niccolo.guicciardini@fastwebnet.it), via Pignolo 123, 24121 Bergamo, BG, Italy. *The quarrel on the invention of the calculus in Jean E . Montucla and Joseph J. L. de Lalande, Histoire des Mathématiques (1758/1799-1802).*

Montucla and Lalande's Histoire des Mathématiques deals with the calculus controversy between Newton and Leibniz in great detail. The purpose of this paper is to analyze the image of the calculus controversy conveyed in this monumental historical work, and to draw some comparisons with contemporary British historical work (Received September 17, 2010)

1067-01-1018 **June E. Barrow-Green*** (J.E.Barrow-Green@open.ac.uk), Faculty of Mathematics, The Open University, Walton Hall, Milton Keynes, MK7 6AA. *George Birkhoff–"the Poincaré of America".*

In 1912, only a few months after the death of Poincaré, the American mathematician George Birkhoff shot to international fame by provided a proof of Poincaré's 'last geometric theorem', a theorem with which Poincaré had struggled during the last two years of his life. Birkhoff continued to work on topics connected with Poincaré, in particular dynamical systems, and went on to become one of the leaders of American mathematics. In my talk, I shall consider Birkhoff as "the Poincaré of America"–a description provided by the Russian mathematician Nikolai Krylov in 1924–setting his work in the context of his career in the United States. (Received September 17, 2010)

1067-01-1044 **Bruce J. Petrie*** (b.petrie@utoronto.ca), IHPST, University of Toronto, Victoria College 316, 91 Charles Street West, Toronto, ON M5S 1K7, Canada. *Johann Lambert's Use and Understanding of Mathematical Transcendence.* Preliminary report.

This paper is part of an ongoing study by the author to understand early notions of mathematical transcendence. The origin of the current definition of a transcendental number has not yet been firmly established. Various historians and mathematicians have in various degrees of certainty credited Leonhard Euler, Johann Lambert, and Joseph Liouville with having established the current definition of a transcendental number. Previous work by the author strongly suggests that Euler's use and understanding of mathematical transcendence is dissimilar to the current use of the term 'transcendental.' Motivated by Michel Serfati's (2010) claim that the first appearance of the modern definition of a transcendental number is to be found in Johann Lambert's (1761/1768) Mémoire, the author presents the results of an investigation into Lambert's general understanding and use of mathematical transcendence. (Received September 17, 2010)

1067-01-1076 **Nathan Sidoli*** (athan.sidoli@utoronto.ca), Waseda Univerity, SILS, 1-6-1 Nishi-Waseda, Shinjuku-ku, Tokyo, Tokyo 169-8050, Japan. *Diagrams and spheres: reflections on an early Arabic edition of Menelaus' Spherics.*

In this talk, I will discuss the use of constructive techniques in Menelaus' *Spherics*, as found in the Arabic version of al-Harawī. Greek geometers, in general, relied on constructions, as a form of geometric operation, for bringing new objects into the domain of discourse so that they could be of use in proving theorems, or solving problems. For any proposition, the full set of given and constructed objects were presented in a single diagram. For texts dealing with spherical geometry, the diagrams preserved in the medieval manuscripts often present real difficulties of interpretation. In this talk, I will argue that the ancient and medieval texts were meant to be read in conjunction with actually doing constructions, before carrying out the reasoning. I will make this argument based on a few striking examples from Menelaus' *Spherics*. (Received September 18, 2010)

1067-01-1078 **Joseph W. Dauben*** (jdauben@att.net), Research Center for Humanities and Social Sciences, National Chiao-Tung University, Hsinchu, 30010, Taiwan. *Early Chinese Mathematics: its Development from pre-Qin to Wei.* Preliminary report.

Recently a collection of some 200 bamboo strips constituting a set of mathematical problems dating to the early third century BCE have been collated and studied at the Yuelu Academy at Hunan University, in Hunan Province, PRC. In conjunction with other similar bamboo slips unearthed from Qin tombs in Hubei Province at Shuihudi and Zhangjiashan, a much clearer picture is beginning to emerge of early Chinese mathematics and its relation to the better-known classic text, the *Jiu Zhang Suan Shu* (Nine Chapters on the Art of Mathematics), with its important commentary of 263 CE by Liu Hui of the Kingdom of Wei. By surveying the development of mathematics in China over this period of more than 500 years, both content and context will be considered, including the types of problems these mathematical works included, the extent to which various arguments and proofs were offered to establish the correctness of results, and how administrative, economic, military and legal matters, among others, are reflected in and may have affected the mathematics contained in these early works. (Received September 18, 2010)

1067-01-1079 **Jesper Lutzen*** (lutzen@math.ku.dk), Jesper Lutzen, Department of Mathematical Sciences, University of Copenhagen, DK-2100 Copenhagen O, Denmark. *The Quadrature of the Circle: 17th century impossibility arguments.*

The classical problem of the quadrature of the circle remained a lively issue during the 17th century. Several solutions were proposed but none of them were generally accepted. On the contrary, several leading mathematicians argued mathematically that the problem was impossible in some sense. The idea of giving mathematical proof of the impossibility of the problem was a new feature in the long history of the problem and deserves special attention. In the talk I shall list various versions of the problem as it was conceived during the 17th century, and discuss why impossibility arguments began to occur at this time. The discussion will involve an analyze three of the impossibility proofs put forward by James Gregory, Isaac Newton and Gottfried Wilhelm Leibniz. (Received September 18, 2010)

1067-01-1090 **Alejandro R. Garciadiego*** (gardan@servidor.unam.mx), Departamento de Matematicas, 016, Facultad de Ciencias, Cd. Universitaria, UNAM, 03700 Mexico, D. F., Mexico. *Gallardo's work, a needle in a haystack.* Preliminary report.

When discussing the origins and development of the professionalization of modern mathematics in Mexico, I have previously studied some factors (e.g., mathematical training, academic visits, printed works, among others) associated with individuals implicated with the creation of the Institute of Mathematics at Universidad Nacional Autonoma de Mexico (1942) and the Mexican Mathematical Society (1943). On this occasion, I would like to discuss a rather unknown pamphlet, printed by Gallardo [1963], on the concept of number, the Pythagorean proposition and the set theoretic paradoxes. In particular, I will try to unveil some of the possible sources he might have consulted and, thus, infer some of his viable intellectual influences. (Received September 18, 2010)

1067-01-1109 **Morteza Seddighin*** (mseddigh@iue.edu), 2325 Chester Blvd., Richmond, IN 47374. *The mathematics of Al-Biruni.*

Abu-Arrayhan Mohammad Ahmad al-Biruni is one of the prominent Iranian scientists of the 10th and 11th century. He has major contributions to mathematics, astronomy, physics, and medicine. We will discuss some of his important contributions to mathematics. (Received September 18, 2010)

1067-01-1110 **Byron E. Wall*** (bwall@yorku.ca), 218 Bethune College, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *The lure of the fundamental probability set of equally likely events.* Preliminary report.

The mathematical theory of probability has its origins in attempts to answer questions about events occurring in games of chance. Probability has now broadened to encompass all manner of events, ranging from elaborate but fully understood human constructions, to prognostications about the behavior of ill-understood events in Nature. To apply the complex apparatus of probability to such a wide range of remarkably different situations, one great leveling device has been used, namely, that all possible outcomes are built from a fundamental probability set of equally likely events. This set comprises the atoms of a probability universe. With a set of equally likely events, the same probability theory that describes the chances in a dice game or on a roulette wheel can be applied to all manner of events in Nature. Without equally likely events, the elaborate apparatus of probability theory cannot be brought to bear. The temptation has been too great to see events as equally likely where there were no grounds for such an assertion, and as a result a great deal of nonsense has been propounded in the name of probability. This is a preliminary report of a work in progress. (Received September 18, 2010)

1067-01-1160 **Tinne Hoff Kjeldsen*** (thk@ruc.dk), Roskilde University, Universitetsvej 1, P.B. 260, 4000 Roskilde, Denmark. *Shades of modernism in understandings of applied mathematics: von Neumann's economic system of equations and Rashevsky's model of cellular multiplication.*

The question whether shades of modernism can be found in applied mathematics in the early twentieth century is discussed based on an analysis of John von Neumann's paper on an economic system of equations from 1937, and Nicolas Raschevsky's talk on physico-mathematical aspects of cellular multiplication from 1934. An analytical model of the modelling process will be presented and used to analyse some reactions from the respective communities of economists and biologists. (Received September 19, 2010)

1067-01-1225 **Karen V. H. Parshall*** (khp3k@virginia.edu), Departments of History and Mathematics, University of Virginia, P. O. Box 400137, Charlottesville, VA 22904-4137. *Mobilizing Mathematics: The American Mathematical Society and World War II.* Preliminary report.

Even before the United States entered into World War II in 1941, the leaders of the American Mathematical Society had formed a War Preparedness Committee in anticipation of what was viewed as the eventuality of the U.S.'s involvement in the conflict. They recognized not only that mathematicians could contribute key technical expertise to the war effort but also that the community's ultimate position in the postwar era would very much depend upon those contributions. This talk will examine the initiatives spearheaded by AMS wartime Presidents—Griffith Evans, Marston Morse, and Marshall Stone—to mobilize America's mathematicians. (Received September 20, 2010)

1067-01-1308 **Tomoko L Kitagawa*** (tomoko_kitagawa@harvard.edu), 2 Divinity Ave, Cambridge, MA 02138. *Math Needs Paper and Imagination?: Embodying the Mathematical Knowledge in 17th century Japan.*

This talk discusses the changes in the mode of calculation in Japan during the 1620s when the oral tradition began to take the form of published booklets for wider distribution. While the first math booklet, the Division, simply recorded the oral chanting method of division, the second booklet, the Unalterable Treatise, introduced further methods of calculations and included pictures and diagrams to explain the solutions. From the above two earliest existent Japanese math books, this talk presents the ways in which mathematics that had always been done in the head went through a transformation: It became something that required paper and imagination starting in the late 1620s.

It was observed by Descartes, Kant, and Heder that intuition and pictorial consciousness were the necessary elements for developing mathematical knowledge. Regarding this theoretical debate, Japanese mathematics booklets show how imaginary diagrams appeared where intuition reached its limit. In other words, I argue that it was the pictorial consciousness, not the intuition, which facilitated the further growth of the methods of calculation in Japan. (Received September 20, 2010)

1067-01-1344 **Erik R. Tou*** (etou@carthage.edu), 2001 Alford Park Dr., Kenosha, WI 53140. *Relative Accuracy of Quadrilateral Area Measurement in the Ancient World.* Preliminary report.

In the ancient world, geometers were concerned primarily with mensuration (the practice of accurate measurement), with the most obvious applications being in construction and surveying. One well-known formula from this time (appearing most famously in the Temple of Horus in Egypt, c. 100 BCE) purports to give the area of a general quadrilateral by taking the means of opposite pairs of sides and then multiplying the means. While this formula is erroneous, it produces highly accurate results when the quadrilateral is nearly rectangular. In this talk, we will examine the relative accuracy of this area formula, including: (1) the fact that it will never underestimate the true area, (2) how to find the interior angle that minimizes error, and (3) how significantly the error varies as the interior angle varies from the ideal. (Received September 20, 2010)

1067-01-1348 **Glen R Van Brummelen*** (gvb@questu.ca), Quest University, 3200 University Blvd, Squamish, BC V0N 1T0, Canada. *The Mathematical Study of Historical Numerical Tables: Successes, Failures, Issues.*

Numerical tables, often relegated to the appendices of the history of mathematics, have nevertheless been crucial in the development of science and mathematics. In pre-modern cultures their appearances and roles have been evaluated periodically, but more careful studies of the tables themselves have been attempted only infrequently. Several successful analyses have allowed us to peer behind the curtain at the largely unrecorded computational culture that supported table-making. A couple of efforts have been made to produce systematic tools for analyzing tables, and these methods have led to successful analyses in diverse tables spanning millennia. Problems in this emerging field range from technical to cultural: certain statistical difficulties in studying mathematically-generated data can arise, and a few uncontrolled studies of tables that claimed dramatic but false conclusions have caused historians to view statistical methods with apprehension. (Received September 20, 2010)

1067-01-1366 **Andrew B Perry*** (perryand@gmail.com), 90 Longfellow Drive, Longmeadow, MA 01106. *Early American Presidents' Mathematical Interests.*

Several early Presidents of the United States had significant interest in mathematics or other connections with the subject. For example, George Washington endorsed a major arithmetic book. John Adams was a schoolteacher before becoming president and owned numerous math books. Thomas Jefferson invented an apportionment method and generally took an avid interest in math. Abraham Lincoln studied Euclid's geometry to improve his logical thinking. We will discuss these and other connections between Presidents and mathematics in as much detail as time permits. (Received September 20, 2010)

1067-01-1433 **Frédéric Brechenmacher*** (frederic.brechenmachher@math.cnrs.fr), 72 rue Myrha, 75018 Paris, France. *On the universalization of matrix decomposition: algebraic practices and their circulations (1830-1930).*

The elaboration of an international theory of matrices in the 1930s highlights the role played by a complex phenomenon of universalization of some methods of decompositions appealing to specific forms of representations. Although this phenomenon took place within no more than a decade, it appealed to the long term interrelations of various practices that used to have different identities and to circulate in distinct networks of texts. This phenomenon challenges not only the usual description of the history of algebra as a progress toward more and more abstraction, but also the importance that has been given to some specific domains or collectives. For instance, while the historiography of algebra has tended to lay the emphasis on German developments in algebraic number theory, the universalization of matrix decomposition highlights the key role played by some circulations of practices between French and American mathematicians at the beginning of the 20th century. The investigation of the identities taken on by such practices that circulated between what we would nowadays consider as various "disciplines" or "communities" raises issues related to the categories usually adopted to describe the collective organizations of knowledge or the social identities of groups of actors. (Received September 21, 2010)

1067-01-1471 **Dominic W Klyve*** (klyved@cwu.edu), 400 E University Way, Ellensburg, WA 98926. *Euler's Rettung: Euler's anonymous work on the limits of mathematics, science, and faith.*

In 1747, Euler wrote (and anonymously published) his *Rettung der gottlichen Offenbahrung* (E92), defending the validity of divine revelation as a valid source of knowledge, while considering perceived inconsistencies in mathematics and science. Drawing on a new translation of the *Rettung*, we shall attempt to elucidate some of Euler's religious views, and draw connections between this work and the work he was doing at the time in astronomy and mathematics. We claim that a close familiarity with Euler's mathematical works of the 1740's is necessary to understand this important document, and we will demonstrate some of the mathematical theorems and problems besetting Euler at this time. (Received September 21, 2010)

1067-01-1547 **Della D. Fenster*** (dfenster@richmond.edu), 28 Westhampton Way, University of Richmond, Richmond, VA 23229, and **Joachim Schwermer**. *George Whaples: A Novice in Emil Artin's Mathematical Circle.*

In this talk, we begin to explore how Emil Artin contributed to mathematical circles without formal publications. We focus on how Artin disseminated ideas about class field theory, and, in particular, how Artin began to work with George Whaples, a young American mathematician who had just completed his Ph.D. at the University of Wisconsin. (Received September 21, 2010)

1067-01-1570 **Roger Hart*** (roger.hart@att.net), Department of History, University of Texas at Austin, 1 University Station B7000, Austin, TX 78712-022. *Chinese Roots of Linear Algebra.*

Beginning in about the first century CE in China, anonymous and likely illiterate adepts practiced an arcane art termed fangcheng (sometimes translated into English as "matrices" or "rectangular arrays"). This art provided procedures for manipulating counting rods on a counting board, which enabled practitioners to produce answers to seemingly insoluble riddles. While we know virtually nothing about these adepts, their practices were occasionally recorded by aspiring literati and incorporated in texts they compiled on mathematical arts, which were then presented to the imperial court, together with prefaces promoting the mathematical arts as the semi-divine invention of sage kings, fundamental to understanding cosmogeny, and essential to ordering the empire.

Fangcheng is remarkable because it is essentially equivalent to the solution of systems of n equations in n unknowns in modern linear algebra. The essential feature of fangcheng is, I argue, visualization of problems in two dimensions as an array of numbers on a counting board and the "cross-multiplication" of entries, which led to general solutions of systems of linear equations not found in Greek or early European mathematics. (Received September 21, 2010)

1067-01-1575 **Jacqueline Feke*** (jfeke@stanford.edu), Introduction to the Humanities, 590 Escondido Mall, Sweet Hall, Second Floor, Stanford, CA 94305. *Ptolemy's justification for the study of mathematics.*

Why study mathematics? For Ptolemy, the second-century mathematician, the answer was simple: mathematics has the most ethical benefits of any area of study. By analyzing the mathematical forms and movements of celestial bodies, for instance, the individual attains a virtuous state in the soul. He becomes a lover of the stars and planets' divine beauty and, as a result, he is able to transform his soul into a state resembling the divine constancy, good order, symmetry, and calm. Ptolemy makes this claim in the introduction to the Almagest, his great compendium of astronomical hypotheses. This claim descends from a centuries-long tradition, promulgated by Plato's Timaeus. Ptolemy breaks with the ancient philosophical tradition, however, by elevating mathematics above every other science. According to Ptolemy's Almagest, mathematics is ethically, epistemologically, and practically the highest area of inquiry. Hence, this paper will explore Ptolemy's multifaceted justification for studying mathematics. (Received September 21, 2010)

1067-01-1857 **Matthew J Haines*** (haines@augsburg.edu), 2211 Riverside Ave, Minneapolis, MN 55454. *Examples of Early 1900 Mathematics Secondary Mathematics.*

To explore and highlight similarities and differences of current 5-12 U.S. mathematics curriculum to early 1900 5-12 grade classroom mathematics, examples are brought into a Math History course for future 5-12 grade teachers. (Received September 22, 2010)

1067-01-1981 **Kirsti Andersen*** (kirsti.andersen@ivs.au.dk). *Lambert's ideas on the use of the ruler in traditional Euclidean constructions.*

Among Johann Heinrich Lambert's many interests was perspective. From early on in his scientific studies until the end of his life he wondered about how to represent all sort of objects, as for instance a rainbow, in a perspective drawing. Perspective also inspired him to take up the challenge of finding out how far one can come with a ruler alone in Euclidean construction and what should be assumed given when a ruler does not suffice. Lambert's investigations led to results that were later rediscovered by Victor Poncelet. (Received September 22, 2010)

1067-01-2027 **Daniel S. Alexander*** (daniel.alexander@drake.edu), Dept. Mathematics and Computer Science, 2505 University Avenue, Des Moines, IA. *Salvatore Pincherle and the 1918* Grand Prix des sciences mathématiques*: The Third Man.* Preliminary report.

We often focus on winners or tragic losers. Such is the case with the 1918 *Grand Prix des sciences mathématiques*. It is well-known that Gaston Julia won the competition. Many know that Pierre Fatou did not – but that was because he did not enter. Samuel Lattès also entered, but died before the prize was announced and was awarded a posthumous honorable mention. Much less is known about the work of the third entrant, the Italian mathematician Salvatore Pincherle. His entry was returned to him and did not receive consideration for the prize. Nor was it ever published. Nevertheless, there is much to learn from those who do not win. Not only do they throw the work of those who win into relief, they give us a glimpse into paths not taken. It is from this perspective that we will examine Pincherle's entry, which we obtained from the Académie's archives. We will describe its mathematical content (one of the highlights is an anticipation of the Mandelbrot set), but we will also discuss what this particular entry tells us about the mathematics that earned the prize. (Received September 22, 2010)

1067-01-2104 **Laura E. Turner*** (lturner@ivs.au.dk), Department of Science Studies, Aarhus Universitet, C.F. Møllers Allé, bygn. 1110, 8000 Aarhus C, Denmark. *Roles of an International Journal:* Acta Mathematica *and Italian Mathematicians, 1882–1927.* Preliminary report.

Gösta Mittag-Leffler's international renown during the late 19th- and early 20th centuries stemmed primarily from his role as the editor of *Acta Mathematica*, considered the first truly international journal of mathematics with respect to both readers and contributors. This is also the main source of his fame today. *Acta* is considered to have been an important journal during Mittag-Leffler's lifetime, and accordingly, historians of mathematics have devoted their efforts to studies of its foundation and administration and to some extent Mittag-Leffler's efforts in promoting international communication in mathematics under its auspices during his editorship, from 1882 to 1927. What we lack, however, are analyses of the ways in which *Acta Mathematica* and Mittag-Leffler as its editor functioned within and between mathematical communities and networks, the ways in which the journal was actually utilized, and the roles it played. This paper provides one such study, focusing on the the uses of and values ascribed to *Acta Mathematica* by Italian mathematicians during Mittag-Leffler's lifetime. (Received September 22, 2010)

1067-01-2343 **Charlotte K. Simmons*** (cksimmons@uco.edu), 100 N. University Drive, Edmond, OK 73012, and **Jesse W. Byrne** (jbyrne@uco.edu), 100 N. University Drive, Edmond, OK 73012. *Felix Hausdorff: Mathematician, Poet, and Playwright.* Preliminary report.

According to a German television broadcast on April 30, 1967, entitled Die Wissenschaftler im Exil (Scientists in Exile), the percentage loss of scholars suffered by the German universities in 1933 was greatest for mathematicians. As many as 144 German-speaking mathematicians can be listed who had to leave their positions and homes after 1933. As Michael Goolomb put it, "Most of them emigrated, but some of them lost their lives." Felix Hausdorff, credited as one of the founders of topology, is amongst these. In this talk, we will explore the life of this great mathematician, astronomer, and litterateur, who wished for his friends that they would "experience better times." (Received September 22, 2010)

1067-01-2354 **Deborah Kent***, Department of Mathematics, Hillsdale College, 33 E. College Street, Hillsdale, MI 49242. *Circulating Mathematics and Connecting Mathematicians: The American Journal of Mathematics, 1878-1930.*

The American Journal of Mathematics (*AJM*) was founded in 1878 with the expressed goal of propagating research mathematics in the United States. Nearly half of the contributions during the first decade came from founding editor J.J. Sylvester and his colleagues at Johns Hopkins University, but the network of contributors and readers gradually expanded. This paper will explore the role of the *AJM* in the delineation of mathematical communities and the development of mathematical themes in the United States. (Received September 22, 2010)

1067-01-2392 **Paul R. Bialek*** (pbialek@tiu.edu), Department of Mathematics, Trinity International University, 2065 Half Day Rd, Deerfield, IL 60015. *Euler's proof that every prime of the form $4n + 1$ is sum of two squares.*

Fermat was the first to conjecture that an odd prime p can be expressed as the sum of two squares $x^2 + y^2$ if and only if p is congruent to 1 (mod 4). In his paper, "Proof of a theorem of Fermat that every prime number of the form $4n + 1$ is a sum of two squares" [E241], Euler outlines a proof of this conjecture. We will present a translation from the Latin and a summary of this previously untranslated paper. (Received September 23, 2010)

1067-01-2423 **Antoni Malet*** (antoni.malet@upf.edu). *Seventeenth-century debates on ratio and proportionality revisited.*

In the 16th and 17th centuries the classical Greek notions of ratio and proportion underwent a major transformation that related them to continuous but measurable magnitudes. The paper studies the changes introduced in the classical notions of ratio and proportion by several seventeenth-century mathematical thinkers. (Received September 23, 2010)

03 ► *Mathematical logic and foundations*

1067-03-62 **Samson Abramsky*** (samson@comlab.ox.ac.uk), Oxford University Computing Laboratory, Wolfson Building, Parks Road, Oxford, OX1 3QD, England. *Relational hidden variables and nonlocality.*

We use a simple relational framework to develop the key notions and results on hidden variables and nonlocality. The extensive literature on these topics in the foundations of quantum mechanics is couched in terms of probabilistic models, and properties such as locality and no-signalling are formulated probabilistically. We show that to a remarkable extent, the main structure of the theory, through the major No-Go theorems and beyond, survives intact under the replacement of probability distributions by mere relations. In particular, probabilistic notions of independence are replaced by purely logical ones.

We also study the relationships between quantum systems, probabilistic models and relational models. (Received September 21, 2010)

1067-03-63 **Andreas Blass*** (ablass@umich.edu), University of Michigan, Mathematics Department, Ann Arbor, MI 48109. *Special Ultrafilters, Generic Ultrafilters, and Partitions.*

The theories of ultrafilters (non-principal, on the natural numbers) and of forcing are linked in several ways. Various notions of forcing produce ultrafilters with interesting properties. Ultrafilters also serve as constituents of other notions of forcing. And the two can be combined: First force to produce an ultrafilter and then use it for further forcing. A recurring theme in the study of such connections is the use of partition properties of ultrafilters, properties related to Ramsey's theorem and its generalizations. I plan to give a survey of these topics, beginning with the simplest sort of generic ultrafilter (with the nicest partition properties) and ending with recent results on other forms of genericity. (Received September 20, 2010)

1067-03-64 **Larry Moss*** (larry.moss@gmail.com), Indiana University, Department of Mathematics, 831 East Third Street, Bloomington, IN 47405-7106. *Final Coalgebras: A Survey.*

The area of coalgebra originated as a general study of discrete dynamical systems aimed at applications in the theory computation. It may be regarded as a generalization of parts of automata theory. But because the generalization is category-theoretic, it has connections with other areas, including ones which might interest participants in the AMS and ASL meetings: universal algebra, non-wellfounded set theory, general topology, modal logic, and even aspects of analysis and combinatorics.

My talk will be an introduction to coalgebra for a mathematics audience. I will be especially concerned with constructions of 'final coalgebras'; these are duals to initial algebras, but the construction methods are usually more intricate, and the resulting objects more interesting. I will try to present as many different examples as possible, hinting at the theory of coalgebra and making the case that it is is a subject of broad interest in logic and mathematics. (Received September 20, 2010)

1067-03-65 **Alf Onshuus*** (aonshuus@uniandes.edu.co), University of Los Andes, Departmento de Matematicas, Cra 1 NO 18A-10 Bloque H, Santa Fe de Bogota, Colombia. *Ordered groups definable in o-minimal theories.*

In this talk we will show that every ordered group G definable in an o-minimal theory (for example the real field) has a normal series $N_1 unlhddotsunlhd N_r = G$ where r is the dimension of G and such that N_{i1}/N_i is a ordered abelian o-minimal group. We will then state results which will bring us closer to a complete characterization of such groups. (Received September 20, 2010)

1067-03-66 **Patrick Speissegger*** (speisseg@math.mcmaster.ca), McMaster University, Mathematics and Statistics Department, 1280 Main Street, Hamilton, ON L8S4K1, Canada. *O-minimality and Hilbert's 16th problem.*

Let F be the family of all polynomial vector fields of degree d in the plane. Hilbert's 16th problem conjectures that there is a finite bound on the number of limit cycles of the vector fields belonging to F. This as yet open problem (if d is at least 2) has a tantalizingly model-theoretic flavor, but no model-theoretic framework has been discovered so far to capture it. On the other hand, Roussarie's finite cyclicity conjecture reduces the problem to a localized (in the parameter space) one. In recent joint work with Kaiser and Rolin, we used o-minimality (a branch of model theory) to establish Roussarie's conjecture in a very special case. Our hope is to extend our approach to a generic case of this conjecture. I will give a survey of the result in the special case and of some of the difficulties we encounter in the generic case. (Received September 20, 2010)

1067-03-67 **Juris Steprans*** (steprans@yorku.ca), York University, Department of Mathematics and Statistics, Toronto, ON M3J 1P3, Canada. *Maximal almost disjoint families.*

Variations on Shelah's construction of a maximal family of almost disjoint subsets of the integers will be discussed. Some of these will answer questions about almost disjoint families, while others will shed light on the original construction of Shelah. (Received September 20, 2010)

1067-03-68 **Monica VanDieren*** (vandieren@rmu.edu), Robert Morris University, Department of Mathematics, Moon Township, PA 15108. *Independence results in the model theory of infinitary logics.*

Initial results in the development of a model theory for infinitary logic were splattered with set theoretic assumptions and sometimes turned to be independent of ZFC. Later on set theoretic assumptions continued to show up in model theoretic results for non-first-order logics because they served as a stand-in for compactness. We will provide a brief history of the interplay between set theory and model theory and highlight some recent advancements. (Received September 20, 2010)

1067-03-88 **James M Henle*** (jhenle@smith.edu), Clark Science Center, Smith College, Northampton, MA 01063. *Breadth, Depth, Disputes, Drama, and Campus Pranks: The Possibilities and Pleasures of Co-teaching Logic.*

I teach introductory logic with philosopher Jay Garfield. The collaboration allows us to reach farther and deeper into logic. The dissonance of our perspectives excites and entertains students. Working together magnifies a natural tendency toward wild and experimental ideas.

The result is a course that teaches basic skills and sophisticated abstractions, breeds logic minors and majors, and keeps the campus on edge. (Received July 21, 2010)

1067-03-391 **Ulrich Kohlenbach*** (kohlenbach@mathematik.tu-darmstadt.de), Ulrich Kohlenbach, Department of Mathematics, Technische Universität Darmstadt, 64289 Darmstadt, Germany. *Uniform Bounds from Proofs in Nonlinear Ergodic and Fixed Point Theory.*

In this talk we present some recent results in the 'proof mining' program of extracting effective uniform bounds from proofs. More specifically, we give

- an effective and highly uniform rate of so-called metastability (in the sense of Tao) for a nonlinear generalization of the Mean Ergodic Theorem due to Wittmann that establishes the strong convergence of an iteration for nonlinear nonexpansive mappings that – in the linear case – coincides with the Cesàro means;
- an effective and uniform bound for a metastable version of Baillon's nonlinear ergodic theorem (this time with weak convergence only) extracted from a proof due to Brézis and Browder of that theorem.

We also mention another 'proof-mining' result (together with D. Körnlein) which gives an explicit convergence rate for an asymptotic regularity result due to Chidume and Zegeye for Lipschitzian pseudocontractive mappings in arbitrary Banach spaces. In the bounded case this rate is polynomial in the data involved. (Received August 31, 2010)

1067-03-547 **Alexander P. Kreuzer*** (akreuzer@mathematik.tu-darmstadt.de), Department of Mathematics, Technische Universität Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt, Germany. *Ramsey's theorem for pairs and program extraction.*

Let Ramsey's theorem for pairs (RT^2_2) be the statement that every coloring of unordered pairs of $\mathbb{N}$ using 2 colors admits an infinite homogeneous set. We present a method for program extraction from proofs that use RT^2_2. (These programs are provably total relative to Σ^0_2-induction.)

Further, we discuss the cohesive principle (COH). This principle is a consequence of RT^2_2. We show that COH together with the infinite pigeonhole principle implies the variant of the Bolzano-Weierstrass principle that states that every bounded sequence of reals contains a slowly converging subsequence. Slowly converging means here that the sequence converges but we do *not* require a explicitly given rate of convergence (which is the case in the formalization of this principle used in reverse mathematics). We present for $\mathrm{COH} +$ infinite pigeonhole principle a method for program extraction that even yields primitive recursive terms.

We also comment on ongoing research. (Received September 09, 2010)

1067-03-669 **Julia F. Knight*** (knight.1@nd.edu), 255 Hurley Hall, Mathematics Department, University of Notre Dame, Notre Dame, IN 46556-5641, and **Karen Lange**. *Structures associated with real closed fields.*

Let R be a countable real closed field. A *value group* for R is a subgroup G of $(R^+, \cdot)$ with just one representative for each equivalence class under the Archimedean valuation. A *residue field* for R is a maximal Archimedean subfield k. An *integer part* is a discrete ordered subring I such that for all $x \in R$, there exists $i \in I$ with $i \leq x < i + 1$.

We showed that R has a value group that is $\Delta^0_2(R)$, and there is a residue field that is $\Pi^0_2(R)$. Both results are sharp. By a result of Mourgues and Ressayre, R has an integer part. Using their procedure, we obtain an integer part that is $\Delta^0_{\omega^\omega}(R)$. For all we know, there is a simpler procedure, yielding an integer part that is $\Delta^0_2(R)$. There is a maximal discrete ordered subring I that is $\Delta^0_2(R)$. Moniri and Marker gave examples showing that this need not be an integer part–I does not extend to a Z-ring. There is a $\Delta^0_2(R)$ ring $I \subseteq R$ such that I is a maximal Z-ring. With Paola D'Aquino, we showed that this need not be an integer part for R. We showed that there is a computable real closed field with no n-c.e. integer part for any n. (Received September 13, 2010)

1067-03-679 **Karen M. Lange*** (klange1@nd.edu), Mathematics Department, 255 Hurley Hall, Notre Dame, IN 46556, and **Julia F. Knight** (knight.1@nd.edu), Mathematics Department, 255 Hurley Hall, Notre Dame, IN 46556. *Generalized power series and exponential real closed fields.* Preliminary report.

An *integer part* I for an ordered field R is a discrete ordered subring containing 1 such that for all $r \in R$ there exists a unique $i \in I$ with $i \leq r < i+1$. Mourgues and Ressayre showed that every real closed field R has an integer part. Let k be the residue field of R, and let G be the value group of R. Let $k\langle\langle G\rangle\rangle$ be the set of *generalized power series* of the form $\Sigma_{g \in S} a_g g$ where $a_g \in k$ and the support of the power series $S \subseteq G$ is well ordered. Mourgues and Ressayre produce an integer part for R by building a special embedding of R into $k\langle\langle G\rangle\rangle$. To understand the complexity of integer parts, we analyzed an algorithmic version of their construction for countable R and showed that the generalized power series in the image of R are of length less than ω^{ω^ω}. Ressayre showed that every real closed exponential field has an integer part that is closed under 2^x using the same approach. However, he had to more carefully choose the value group G and the embedding of R into $k\langle\langle G\rangle\rangle$. We explore how these alterations affect the lengths of the generalized power series in the image of R. (Received September 13, 2010)

1067-03-705 **Ivo M. Babuska**, **Uday Banerjee** and **Hengguang Li*** (li_h@ima.umn.edu), IMA, University of Minnesota, Minneapolis, MN 55455. *The effect of numerical integration on the finite element computation of linear functionals.*

It is well known that the discretization of a finite element method results in a linear system of equations, in which the matrix and the load vector are usually computed by numerical integration. The inexact integration may lead to a different linear system, and consequently, produce a different finite element solution. In this talk, starting with a brief discussion on the existing results regarding the impact of quadrature rules on the finite element approximation in the energy norm, we will present a sharp estimate on the convergence rate of the finite element approximation with numerical integration for linear functionals. (Received September 13, 2010)

1067-03-724 **Johan G. F. Belinfante*** (belinfan@math.gatech.edu), 1238 Jody Lane NE, Atlanta, GA 30329-3520. *The GOEDEL Program.*

The GOEDEL program is an ever-growing collection of currently more than thirty thousand rewrite rules for transforming expressions in Gödel's class theory in the hope of thereby simplifying them. In this talk a brief survey of the program and its use will be presented. A few striking results obtained using the program are featured to provide some of the flavor of the author's on-going research over the past fifteen years. (Received September 16, 2010)

1067-03-727 **Eyvind Martol Briseid*** (briseid@mathematik.tu-darmstadt.de), Department of Mathematics, Technische Universität Darmstadt, Schlossgartenstrasse 7, 64289 Darmstadt, Germany. *Proof mining in nonstandard analysis.* Preliminary report.

We will present a functional interpretation for nonstandard arithmetic in all finite types, and discuss its possible use in unwinding proofs based on nonstandard methods.

This is joint work with Benno van den Berg and Pavol Safarik. (Received September 14, 2010)

1067-03-729 **Kerry Ojakian*** (kerryojakian@gmail.com). *A characterization of computable analysis on unbounded domains using differential equations equations.*

I will present joint work with Manuel L. Campagnolo. The functions of Computable Analysis are defined by enhancing the capacities of normal Turing Machines to deal with real number inputs. We consider characterizations of these functions using function algebras, known as Real Recursive Functions (Moore 1996). Bournez and Hainry (2006) used a function algebra to characterize the twice continuously differentiable functions of Computable Analysis, restricted to certain compact domains. In our CCA paper of 2008, we developed a different function algebra that also yields Computable Analysis, still limited to twice continuously differentiable functions of Computable Analysis, restricted to certain compact domains. In recent work, we improve our result, finding three characterizations of Computable Analysis, removing the restriction to twice continuously differentiable and allowing unbounded domains. Furthermore, the recent proof uses our "method of approximation" from our earlier work (Archives paper of 2008), providing further evidence of our claim that this technique should have wide applicability in work of this kind. (Received September 14, 2010)

1067-03-737 **Vassilios Gregoriades*** (gregoriades@mathematik.tu-darmstadt.de), Arbeitsgruppe Logik, Fachbereich Mathematik, Technische Universität Darmstadt, Schloßgartenstr. 7, 64289 Darmstadt, Germany. *Applications of Logic to Analysis.*

In this talk we present some interactions of Effective Descriptive Set Theory and Analysis. We focus on results concerning the existence of Δ^1_1 (or HYP) members in some particular sets which arise naturally in Analysis. This kind of theorems lead to results about Analysis for which no "classic" i.e., non-effective proof is known. In particular we give two such examples, one of G. Debs' and one of the speaker's. In the first one we present the existence of a particular choice function which is Borel-measurable and in the second one a dichotomy result about sequences in Banach spaces. (Received September 14, 2010)

1067-03-741 **Ning Zhong*** (Ning.Zhong@uc.edu), Department of Mathematical Sciences, University of Cincinnati, 816 Old Chemistry Building, Cincinnati, OH 45221-0025. *Computability and Complexity of Computable Cauchy Problems.*

In this talk, we discuss computability, non-computability, and complexity aspects of solutions, life spans, blowup times, and limiting behaviors of computable Cauchy problems for differential equations. We will present a sample of results and give some idea of the motivation and general philosophy underlying these results. (Received September 14, 2010)

1067-03-750 **Henry P Towsner*** (htowsner@gmail.com), Department of Mathematics, University of California, Box 951555, Los Angeles, CA 90095. *Beyond the Correspondence Principle.*

The Correspondence Principle gives a means for translating problems in combinatorics to problems in ergodic theory, and vice-versa. While Furstenberg's original proof was purely combinatorial, we will discuss the variant proof using nonstandard analysis. Recent work, most notably by Hrushovski, has shown that far more information can be preserved by the correspondence, making it possible to obtain combinatorial information from more subtle arguments on the analytic side. (Received September 14, 2010)

1067-03-794 **Nathanael L. Ackerman** (nate@math.berkeley.edu), University of California, Berkeley, **Cameron E. Freer*** (freer@math.hawaii.edu), University of Hawaii at Manoa, and **Rehana R. Patel** (patel@math.harvard.edu), Harvard University. *Invariant measures on countable models.*

The Erdős-Rényi random graph construction can be seen as inducing a probability measure concentrated on the Rado graph (sometimes known as the countable "random graph") that is invariant under arbitrary permutations of the underlying set of vertices. The following question arises naturally: On which countable combinatorial structures is there such an invariant measure? Up until recent work of Petrov and Vershik (2010), it was not even known if Henson's universal countable triangle-free graph admitted an invariant measure.

We provide a complete characterization of countable structures admitting invariant measures, in terms of the model-theoretic notion of *definable closure*. This leads to a characterization for ultrahomogeneous structures, as well as new examples of invariant measures on graphs, trees, and other combinatorial structures. (Received September 14, 2010)

1067-03-836 **Georges Gonthier*** (gonthier@microsoft.com), Microsoft Research Cambridge, 7 JJ Thomson avenue, Cambridge, CB3 0FB, England. *Mechanizing the Odd Order Theorem: Local Analysis.*

In addition to formal definitions and theorems, mathematical theories also contain clever, context-sensitive notations, usage conventions, and proof methods. To mechanize advanced mathematical results it is essential to capture these more informal elements. This can be difficult, requiring an array of techniques closer to software engineering than formal logic, but it is essential to obtaining formal proofs of graduate-level mathematics, and can give new insight as well. In this talk we will give several examples of such empirical formal mathematics that we have encountered in the process of mechanizing the large corpus of Group Theory required by the Local Analysis part of the Odd Order Theorem. (Received September 15, 2010)

1067-03-854 **Thomas C. Hales*** (hales@pitt.edu), Math Department, University of Pittsburgh, Pittsburgh, PA 15260. *The Kepler Conjecture after 400 years: from conjecture to formal proof.*

In 1611, J. Kepler asserted that no packing of congruent balls can have density greater than the familiar pyramid arrangement that is used for cannonballs at war memorials. This year we celebrate the 400 year anniversary of the publication of the booklet that contains Kepler's assertion. By now, most parts of the proof of Kepler's assertion have been encoded as a formal proof. This talk with trace the transformation of the solution of the

Kepler conjecture, from a conventional proof that relies on computer calculations, towards a machine-checkable formal proof. (Received September 15, 2010)

1067-03-860 **Josef Urban*** (Josef.Urban@gmail.com), Intelligent Systems, ICIS / FNWI, Radboud Universiteit Nijmegen, Postbus 9010, 6500 GL Nijmegen, Netherlands. *Automated Reasoning for Mizar.*

Formal mathematics allows unusually deep cooperation between computers and humans. Computers get access to the full semantics of formally expressed human ideas, and in turn, they can help humans with answering their formally expressed questions, using chains of precise deductive steps. In large formal libraries, precise deduction can be combined with inductive (e.g., learning and heuristic) methods, similar to the methods used for indexing and searching large non-semantic data collections (e.g., the Web). Such combinations can give rise to interesting AI systems.

In the recent years, Mizar and its large formal library have become a subject of such experiments in Automated Reasoning and Artificial Intelligence. The first results are Automated Reasoning and AI systems that process the whole Mizar library (more than 50000 theorems), and are capable of proving mathematical theorems expressed in the formal Mizar language within seconds.

In this talk, we will demonstrate the use of these systems. We will show how strong automated theorem provers (ATPs) can be used to prove Mizar lemmas, how machine learning systems can be used to advise with selection of knowledge from the large Mizar library, and (time permitting) we will explain how these systems work. (Received September 15, 2010)

1067-03-864 **Jack H Lutz*** (lutz@cs.iastate.edu), Department of Computer Science, 226 Atanasoff, Iowa State University, Ames, IA 50011. *Computability and Complexity in Geometric Measure Theory.*

We discuss recent developments and future directions in computable fractal geometry and the theory of computable curves. (Received September 15, 2010)

1067-03-910 **Jeremy Avigad*** (avigad@cmu.edu), Department of Philosophy, Baker Hall 135, Carnegie Mellon University, Pittsburgh, PA 15213. *Type inference in finite group theory.*

As in the theory of programming languages, "type inference" is used in formal verification to infer parts of the meaning of a syntactic expression, making use of the domains and structures that objects of the expression are known to inhabit. For example, it can mean inferring that a multiplication symbol refers to multiplication in a particular group, inferring that a particular subset construction denotes a group in and of itself, or inferring that another expression denotes a partial morphism between groups, with a particular domain. In this talk, I will describe some of the mechanisms for type inference that are used in the project, directed by Georges Gonthier, of obtaining a formal verification of the Feit-Thompson odd order theorem. (Received September 16, 2010)

1067-03-947 **Vincent N Guingona*** (vincentg@math.umd.edu), Mathematics Building, University of Maryland, College Park, MD 20742-4015. *On definability of types in dependent theories.*

We explore various notions of definability of types for dependent theories with an aim toward generalizing some results from stability theory. The main notion studied is uniform definability of types over finite sets (UDTFS). We examine what theories have this property and what this property implies. For example, we show that dp-minimal theories have UDTFS and explore the relationship between UDTFS and VC-density. Finally, we discuss UDTFS in the context of valued fields. We show that, given a theory of valued fields that eliminates field quantifiers, if the theory of the value group and the theory of the residue field have UDTFS, then the whole theory has UDTFS. (Received September 16, 2010)

1067-03-1168 **Charles Steinhorn*** (steinhorn@vassar.edu), Department of Mathematics, Vassar College, 124 Raymond Ave, Poughkeepsie, NY 12604. *On linearly ordered structures of finite rank.*

This is joint work with A. Onshuus concerning the development of a model theory for linearly ordered structures of finite rank, in which o-minimal structures have rank one (and degree one). In this talk, an analysis of linear orders of finite rank is presented, which in particular includes all linear orders definable in o-minimal structures. Potential applications also will be discussed. (Received September 19, 2010)

1067-03-1396 **Fairouz Kamareddine*** (fairouz@cedar-forest.org), School of Mathematics and Computer Sc, Heriot-Watt University, Riccarton, Edinburgh, Edinburgh, MidLothian EH145AW. *Computerising Mathematical texts with MathLang.*

Mathematical texts can be computerised in many ways. At one end there is document imaging, at the other there are proof assistants (Mizar, Isabelle, Coq, etc.).In between, there are typesetting (e.g., LaTeX and MathML) and semantically oriented (e.g., OpenMath and OMDoc) systems. MathLang is an approach for computerising mathematical texts which is flexible enough to connect the different approaches to computerisation, allowing various degrees of formalisation and compatibility with different logical frameworks (set/category/type theory) and proof systems.

MathLang adds, checks, and displays various information aspects on mathematical texts. One aspect is a weak type system that assigns categories (term, statement, noun, adjective, etc.) to parts of the text, and checks that grammatical sense is maintained. Another aspect allows identifying chunks of text, marking their roles (theorem, definition, explanation, example, section, etc.), and indicating relationships between the chunks (A contradicts B, A follows from B, etc.). Further aspects allow additional formality such as proof structure and details of how a human-readable proof is encoded into a fully formalised version of Mizar/Isabelle/Coq. In this talk we survey the status of the MathLang project. (Received September 20, 2010)

1067-03-1487 **Paul Baginski*** (baginski@gmail.com), Institut Camille Jordan, Batiment Braconnier, Universite Lyon 1, 69622 Villeurbanne, France. *Rings Arising in a Stable Context.*

In the late 1970s, several model theorists, notably Macintyre, Cherlin, Reineke, Felgner, Baur, Newelski and Poizat, to name a few, began examining model theoretic properties in the context of algebraic structures, such as groups and rings. For example, Baldwin and Rose proved that a stable, $\aleph_0$-categorical ring (not assuming commutativity or identity) is nilpotent by finite. They conjectured further that such rings must be null by finite, i.e. multiplication is trivial (up to extension by a finite ring). We will discuss recent developments to extend these arguments to other rings and ring-like structures which may arise out of models of a stable theory. (Received September 21, 2010)

1067-03-1581 **Jeffry L. Hirst*** (jlh@math.appstate.edu), Department of Mathematical Sciences, Appalachian State University, Boone, NC 28608, and **Carl Mummert**, Mathematics Department, Marshall University, One John Marshall Drive, Huntington, WV 25755. *Reverse mathematics and constructive analysis.*

When certain statements are provable in subsystems of constructive analysis using intuitionistic predicate calculus, related sequential statements are provable in weak classical subsystems. For example, for formulas Φ of a special sort, if a sentence $\forall X \exists Y \, \Phi(X, Y)$ is provable using $\mathsf{E\text{-}HA}^\omega$, then the related sequential form

$$\forall \langle X_n \mid n \in \mathbb{N} \rangle \ \exists \langle Y_n \mid n \in \mathbb{N} \rangle \ \forall n \ \phi(X_n, Y_n)$$

is provable in RCA. We call our theorems "uniformization results" because the provability of the sequential form demonstrates a kind of uniformity in the proof of the original sentence. The contrapositives of these uniformization results allow us to apply techniques of reverse mathematics to show the non-provability of statements in constructive axiom systems. (Received September 21, 2010)

1067-03-1628 **Michael A. Tychonievich*** (tycho@math.osu.edu), 629 Math Tower, 231 West 18th Avenue, Columbus, OH 43210. *The Set of Restricted Complex Exponents for Expansions of the Reals.* Preliminary report.

We introduce the set of definable restricted complex powers for o-minimal expansions of the real field. We calculate it explicitly for structures of the of the form $(\overline{\mathbb{R}}, (x^z \restriction [1,2])_{z \in Z})$ where Z is a subset of the field of complex numbers. For many of these structures, we produce examples of holomorphic functions that are definable and yet not semialgebraic. (Received September 22, 2010)

1067-03-1711 **John R Harrison*** (johnh@ichips.intel.com), 3204 SW 153rd Drive, Beaverton, OR 97006. *The HOL Light formalization of Euclidean space.*

Over the last few years, we and others have been developing a fairly large library of formalized theorems about Euclidean space in the HOL Light theorem prover. This includes basic properties of vectors, linear algebra, topological notions, some results on convex sets in general and polytopes and polyhedra in particular, Frechet derivatives, measure and (gauge) integration, and geometrical notions. A supplementary library uses this background to develop complex analysis including a version of Cauchy's theorem, and this has been applied to formalize an analytic proof of the Prime Number Theorem. The library as a whole provides the basic background for the Flyspeck project to formalize the proof of the Kepler conjecture, and some parts have been developed explicitly to support this effort. I will present some of the highlights of this work. (Received September 21, 2010)

1067-03-1782 **William M Farmer*** (wmfarmer@mcmaster.ca), Computing and Software, ITB 202, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1. *Modules for a Large Library of Formalized Mathematics.* Preliminary report.

Like any other complex system, a large library of formalized mathematics needs to be constructed from modular units. What requirements should a system of such modules satisfy? First, the system should include powerful methods for building complex knowledge structures by combining and relating modules. Second, the system should enable mathematical knowledge to be expressed both declaratively (using axioms) and procedurally (using algorithms). Third, the system should serve both the developers who build the library and the end users who use the library. We will discuss these requirements and present several ideas for satisfying them. We will also argue that a module system that satisfies these requirements must contain a variety of different kinds of modules.

This is joint work with Jacques Carette. (Received September 21, 2010)

1067-03-1867 **Meghan B Anderson***, Department of Mathematics, 970 Evans Hall, Berkeley, CA 94720-3840. *Solutions of linear equations in a model complete theory of valued D-fields.*

Scanlon's model complete theory of valued D-fields combines difference and differential fields into one structure with good model theoretic properties; however some simple equations can never have solutions in this setting. I will show that the dimension of the space of solutions to a linear difference equation over the constants of such a field is determined by the structure induced on the residue field. (Received September 22, 2010)

1067-03-1880 **Koushik Pal*** (koushik@math.berkeley.edu). *Model theory of multiplicative valued difference fields.*

A *valued difference field* (K, σ, v) is a valued field (K, v) with a field automorphism $\sigma : K \to K$, satisfying $\sigma(\mathfrak{O}_K) = \mathfrak{O}_K$, where $\mathfrak{O}_K$ is the ring of integers. The theory of such a structure depends on how the automorphism interacts with the valuation function. If (K, σ, v) satisfies $v(\sigma(x)) = v(x)$ for all $x \in K$, the valued difference field is called *isometric*. The model theory of such structures has been studied by Luc Bélair, Angus Macintyre and Thomas Scanlon. If (K, σ, v) satisfies $v(\sigma(x)) > nv(x)$ for all $n \in \mathbb{N}$ and for all $x \in K^\times$ such that $v(x) > 0$, the valued difference field is called *contractive*. The model theory of such structures has been studied by Salih Azgin. I am going to talk about a more general case, which incorporates the above two cases, and which we call *multiplicative*. A multiplicative valued difference field satisfies $v(\sigma(x)) = qv(x)$, where q (> 0) is interpreted as an element of a real-closed field. For example, q could be 2, i.e., $v(\sigma(x)) = 2v(x)$. I will give axiomatization for such theory, prove an Ax-Kochen-Ershov kind of result and show that the theory admits relative quantifier elimination. (Received September 22, 2010)

1067-03-2034 **Peter Buser*** (peter.buser@epfl.ch), Ecole Polytechnique Fédérale, SB-IGAT-GEOM, Station 8, CH-1015 Lausanne, Switzerland, and **Bruno Scarpellini** (bscarpellini@hotmail.com), Professor Bruno Scarpellini, Mathematisches Institut der Universität, Rheinsprung 21, CH-4051 Basel, Switzerland. *Recursive analysis of singular ordinary differential equations.*

The lecture deals with the decision of recursively enumerable sets by analog machines. The "analog machine" is an integration analyzer of Fourier coefficients of real or complex valued functions. The main result to be presented is a characterization of the recursively enumerable sets by Fourier coefficients of recursive analytic functions that are generated by certain ordinary differential equations and elementary operations such as addition multiplication and integration. (Received September 22, 2010)

1067-03-2055 **Thomas Warren Scanlon*** (scanlon@math.berkeley.edu), UC Berkeley, Department of Mathematics, Evans Hall, Berkeley, CA 94720-3840. *Model theory of fields with operators and dynamics.*

We have known for some time that questions in algebraic dynamics may be expressed in terms of difference algebra and then solved using the model theory of difference fields. I shall discuss an alternate approach whereby some instances of the dynamical Mordell-Lang problem may be addressed by the model theory of Hasse differential fields. (Received September 22, 2010)

1067-03-2144 **Thomas Warren Scanlon*** (scanlon@math.berkeley.edu), UC Berkeley, Department of Mathematics, Evans Hall, Berkeley, CA 94720-3840. *Counting special points: logic, Diophantine geometry and transcendence theory.*

I shall describe Jonathan Pila's recent unconditional proof of the André-Oort conjecture for powers of the j-line. While the theorem itself is beautiful, it is the proof which is really the most spectacular part of Pila's contribution in that he employs ideas from disparate areas and mathematical logic, in the form of the study of definability in o-minimal expansions of the real field is the central actor.

By an o-minimal expansion of the real field $(\mathbb{R}, +, \cdot, 0, 1, \leq, \cdots)$ we mean that we consider the real numbers as a first-order structure with at least the usual field operations and the usual order relation but possibly with other distinguished functions and relations so that every definable subset of the line is a finite union of points and intervals. Refining decomposition and parametrization theorems for sets definable in o-minimal structures, Pila and Wilkie produced upper bounds for the numbers of rational points lying on definable sets.

Using results of Peterzil and Starchenko on the definability of the j-function, Pila leverages the upper bounds on the number of rational points in definable sets against lower bounds on the size of the Galois orbits of CM points to prove his theorem. (Received September 22, 2010)

1067-03-2275 **Matthew Anthony Jura*** (matthew.jura@manhattan.edu), 3611 Henry Hudson Pkwy, Apt 2B, Bronx, NY 10463. *Comparing the Weak and Strong Omega Coloring Number of Graphs.*

We use the program of reverse mathematics to analyze the proof theoretic strength of a theorem involving the coloring number of graphs. Classically, the coloring number of a countable graph G, written $\mathrm{Col}(G)$, is the least $k \leq \omega$ such that there is a well ordering of the vertices of G for which each vertex $v \in G$ has at most k many predecessors connected to v by an edge. In the context of reverse mathematics, we formulate notions of weak and strong ω coloring number of a graph G. The "ω" means that the well ordering witnessing $\mathrm{Col}(G)$ has order type ω. In the strong version, the well ordering must be given explicitly by a bijection from $\mathbb{N}$ to the vertex set of G; for the weak version, we only know there is some finite bound on the number of vertices below a given vertex in the ordering. We uncover similarities and differences between these two notions of coloring number. (Received September 22, 2010)

1067-03-2427 **Deirdre Haskell*** (haskell@math.mcmaster.ca), Department of Mathematics and Statistics, McMaster University, 1280 Main St W, Hamilton, ON L8S 4K1, Canada, **Ehud Hrushovski**, , Canada, and **Dugald Macpherson**, , Canada. *Unexpected imaginaries in valued fields with analytic structure.* Preliminary report.

There is a reasonable notion of restricted analytic function on a valued field. With appropriate closure properties on the class of analytic functions, various theories of valued fields with analytic structure have been shown to have quantifier elimination (Cluckers, Lipshitz, Schoutens, etc). The question of whether these theories would also eliminate imaginaries to the sorts which suffice in the algebraic case remained. I will present an example, due to myself, Hrushovski and Macpherson, of an analytically-defined imaginary which cannot be eliminated in the geometric sorts. (Received September 23, 2010)

05 ► Combinatorics

1067-05-13 **Alexander Lubotzky*** (alexlub@math.huji.ac.il), The Hebrew University of Jerusalem, Jerusalem, Israel. *Expander graphs in pure and applied mathematics, I.* Preliminary report.

This is the first of three lectures in which we will describe expander graphs, their properties and their growing role in computer science, and in pure mathematics.

Expanders are sparse graphs (i.e. graphs on n vertices, with $n \to \infty$, while the valency k is bounded) that are still "very much connected". Random walks on such graphs converge very fast to the uniform distribution. The initial interest came from the computer science community, where expanding graphs play a basic role in many communication networks, algorithms and more.

While it is easy to show that expander graphs exist (by random consideration á la Erdős) it is non trivial to give explicit constructions. Various deep mathematical tools, such as Kazhdan Property (T), Ramanujan conjecture, sum-product results have been applied to this goal, as well as a more direct combinatorial construction "the Zig-Zag product". In the first talk, we will give the basic (different) definitions, examples and constructions and illustrate some of the applications. (Received September 16, 2010)

1067-05-29 **Bangteng Xu*** (bangteng.xu@eku.edu), Eastern Kentucky University, Richmond, KY 40475. *Common Divisor Graphs of Permutation Groups and IP-graphs of Association Schemes.*

Isaacs and Praeger studied the common divisor graph of a permutation group. Their main results deal with the number of connected components of the graph, and the diameter of each nontrivial component. For a group G and its subgroup A, Kaplan proved that if A is stable in G and the common divisor graph of (A, G) has two components, then G has a nice structure. The action of G on a set X induces an association scheme (X, S). Camina introduced the IP-graph of a naturally valenced association scheme, and proved that the main results of Isaacs and Praeger are also true for the IP-graph of a naturally valenced association scheme with paired valencies equal. In this talk we will first present similar results for IP-graphs of naturally valenced association schemes without the assumption that all paired valencies are equal. These results generalize the results of Isaacs and Praeger, and Camina. Then for the IP-graph of a naturally valenced association scheme (X, S) that is stable and has two nontrivial components, we show that S has a closed subset T that has very nice properties. Applying these results to common divisor graphs of groups, we obtain the results of Kaplan as direct consequences. (Received June 03, 2010)

1067-05-32 **Lucas J. Rusnak***, Department of Mathematical Sciences, Binghamton University, Binghamton, NY 13902. *Oriented Hypergraphs and the Structure of Rational Matrices.*

An *oriented hypergraph* is an oriented incidence structure which extends the concept of a signed graph. Just as signed graphs provide a model for $\{0, \pm 1\}$-matrices with exactly two non-zero entries in each column, an oriented hypergraph provides a similar model for any rational matrix. I will survey the current state of the theory of oriented hypergraphs and the progress made towards the circuit classification of rational matrices.

Topics discussed will include a brief introduction of new hypergraphic structures and operations relevant to the classification of column dependencies of rational matrices, the decomposition of oriented hypergraphs into three families of varying degrees of "balance", the identification of the minimal hypergraphic obstructions to balanceability, and the current state of the circuit classification theorem for rational matrices. (Received June 08, 2010)

1067-05-43 **Tyler Seacrest*** (s-tseacre@math.unl.edu), University of Nebraska, Department of Mathematics, 203 Avery Hall, Lincoln, NE 68588-0130, and **Stephen G. Hartke** (hartke@math.unl.edu), University of Nebraska, Department of Mathematics, 203 Avery Hall, Lincoln, NE 68588-0130. *Large 1-factorizable subgraphs.*

Assume G is a graph on n vertices, n even, with minimum degree $n/2$. Katerinis, and later Egawa and Enomoto, proved that G has a k-factor for some k at least $n/4$. Is it possible to get a similar result for edge-disjoint 1-factors instead? As Katerinis points out, the best known result in this direction follows from the work of Nash-Williams, gives that G has at least $n/23$ edge-disjoint one-factors.

Our contribution is that if G has minimum degree $n/2 + o(n)$, then it has k edge-disjoint 1-factors for some k at least $n/8$. Furthermore, if n is a perfect square, then G has k edge-disjoint 1-factors for $k = n/4 - o(n)$. (Received June 12, 2010)

1067-05-84 **Bobbe J. Cooper** and **Eric S. Rowland*** (erowland@tulane.edu), Mathematics Department, Tulane University, New Orleans, LA 70118, and **Doron Zeilberger**. *Toward a language theoretic proof of the four color theorem.*

Consider the simple context-free grammar G consisting of start symbols $0, 1, 2$ and formation rules $0 \to 12$, $0 \to 21$, $1 \to 02$, $1 \to 20$, $2 \to 01$, $2 \to 10$. Observe that G is ambiguous — there exist distinct trees that parse the same word. For example, the trees `((()())())` and `(()(()()))` both parse the word 010.

However, something much stronger can be said about this grammar.

Theorem 1. *The grammar G is totally ambiguous.*

That is, for every pair of n-leaf derivation trees, there exists a length-n word on $\{0, 1, 2\}$ that both trees parse. In 1990 Louis Kauffman proved this theorem by showing that it is equivalent to the four color theorem.

Here we take the opposite approach, the hope being to prove Theorem 1 directly and thereby obtain a shorter proof of the four color theorem as well as additional insight. In this direction we enumerate the common parse words for several infinite families of tree pairs and discuss ways to reduce the problem of finding a parse word for a pair of trees to that for a smaller pair. (Received July 20, 2010)

1067-05-123 **Lindsay Anne Merchant*** (Lindsay.Merchant@ndsu.edu), 21 South Broadway #406, Fargo, ND 58103. *A Nim-type game played on the complete graph.*

The two-player game of Nim on graphs is played on a simple 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 a player is unable to move since all edges incident with the vertex from which the player is to move have weight zero. In this paper, we consider previously known results to this game, offer new strategies to the game on specific graphs, and give a solution to the complete graph with arbitrary weight. We also consider Nim on the n-Cube, and Nim on trees. (Received July 26, 2010)

1067-05-130 **Joanna A. Ellis-Monaghan*** (jellis-monaghan@smcvt.edu), One Winooski Park, Colchester, VT 05439, and **Iain Moffatt**, VT. *Ribbon Graphs and Twisted Duality.*

We consider two operations on the edge of an embedded (*i.e.* ribbon) graph: giving a half-twist to the edge and taking the partial dual with respect to the edge. These two operations give rise to an action of ${S_3}^{e(G)}$, the *ribbon group of* G, on G. We show that this ribbon group action gives a complete characterization of duality in that if G is any cellularly embedded graph with medial graph G_m, then the orbit of G under the group action is precisely the set of all graphs with medial graphs isomorphic (as abstract graphs) to G_m. We then show how this group action leads to a deeper understanding of the properties of, and relationships among, various graph polynomials such as the generalized transition polynomial, an extension of the Penrose polynomial to embedded graphs, and the topological Tutte polynomials of Las Vergnas and also Bollobás and Riordan, as well as various knot and link invariants. (Received July 26, 2010)

1067-05-139 **Ligo G Richard*** (ligorg@westminster.edu), 924 Westminster College, New Wilmington, PA 16172, and **Larson-Koester R Miriam**. *The Subgraph Summability Number of a Graph.*

Given a graph G, a vertex labeling of G is a mapping $\alpha : V(G) \to \mathbb{N}$, assigning a positive integer value to each vertex. With this we can consider labels of connected induced subgraphs $G[U]$ for $U \subseteq V(G)$, and define $\alpha(G[U]) = \sum_{u\in U} \alpha(u)$. The subgraph summability number of a connected graph G is the largest integer $\sigma(G)$ so that the label sums of connected induced subgraphs cover the integers 1 through $\sigma(G)$. The question of graph labeling is intimately related to ideas in number theory and combinatorics. We investigate summability labelings for cycles, centipede graphs, circulant graphs, and multipartite graphs and generalize their behavior. (Received July 27, 2010)

1067-05-190 **Amin Bahmanian*** (mzb0003@auburn.edu), Department of Mathematics and Statistics, Parker Hall 221, Auburn University, Auburn, AL 36849. *Amalgamations and Detachments of Hypergraphs.*

In this talk, we show how graph amalgamation can be generalized to hypergraphs. We exhibit some applications of our method in decompositions of hypergraphs into factors and embedding partial decompositions (hyperedge-colorings) problems. (Received September 22, 2010)

1067-05-208 **Leon Chang** (lc2585@columbia.edu), 6540 Lerner Hall, 2920 Broadway, New York, NY 10027, and **Siddharth S Raval*** (ravals@reed.edu), 3203 SE Woodstock Blvd, MS #889, Portland, OR 97202. *Complex Contagions on Graph Dynamical Systems.*

Many social contagions require multiple contacts or sources of activation to spread. Examples include adoption of new technologies, participation in social movements, etc. Such processes are called complex contagions. These have so far been modeled on graphs by threshold systems with fixed thresholds.

However, a fixed threshold does not capture the dynamics of systems involving varying disease immunity, evolving psychological factors in social contagions, etc. We generalize the notion of threshold systems to incorporate the effects of dynamics and history. Namely, we have increasing, decreasing, and mixed thresholds that better reflect realistic dynamics; we call this generalization an evolving threshold dynamical system (ET-DS).

Using the framework of graph dynamical systems, we characterize the long-term behavior of dynamic threshold systems, enumerate the number of limit sets, describe the phase spaces of such systems and, in the process, elucidate topological conjugacies between dynamical system maps of these threshold functions. We then consider ET-DSs on some specific graph classes, deriving explicit formulae for the number of fixed points. (Received August 03, 2010)

1067-05-220 **Lerna Pehlivan*** (pehlivan@math.carleton.ca), 1125 Colonel By Drive, Ottawa, Ontario K1S 5B6, Canada. *Top to random shuffles and number of fixed points.* Preliminary report.

Initially we order n cards, 1 at top through n at bottom. We provide the formulas for the expected value and the variance of the number of fixed points of a permutation obtained after a number of *top to random shuffles*.

We give two different proofs for each result. We also show that $O(cn)$ top to random shuffles are not enough to achieve convergence to a Poisson(1). (Received August 08, 2010)

1067-05-227 **Elizabeth M Niese*** (eniese@vt.edu), 460 McBryde Hall, Blacksburg, VA 24060, and **Nicholas Loehr** (nloehr@vt.edu). *Divisibility properties and recursions for the Hilbert series of Macdonald polynomials.*

In this presentation we look at $\widetilde{F}_\mu(q,t)$, the Hilbert series of Macdonald polynomials. We use the combinatorial definition of $\widetilde{F}_\mu$ to prove that $\widetilde{F}_\mu$ is divisible by certain factors. To prove this bijectively we introduce a recursion for two-column shapes along with several combinatorial operations on the fillings which generate $\widetilde{F}_\mu$. This recursion also leads to a fermionic formula which expresses $\widetilde{F}_{(2^n)}(q,t)$ as a sum indexed by perfect matchings. (Received August 10, 2010)

1067-05-253 **Jill Bigley Dunham***, 401 Rosemont Ave., Frederick, MD 21701. *Extremal coin graphs on multiple radii.* Preliminary report.

In this research, we consider extremal coin graphs in the Euclidean plane. The problem of determining the maximum number of edges of a unit coin graph on n vertices has been solved previously by Heiko Harborth. We generalize the problem to coin graphs with multiple possible radii. A motivating problem is a special case of a coin graph with two possible radii. (Received August 13, 2010)

1067-05-311 **Peter Richter***, Department of Mathematics, 601 Elmwood Avenue, University of Rochester, Rochester, NY 14642-0002, **Emily Sergel**, Department of Mathematics, Rutgers University, Hill Center for the Mathematical Sciences, 110 Frelinghuysen Rd., Piscataway, NJ 08854-8019, and **Anh Tran**, School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14623. *Rank numbers for generalized ladders, some trees and unicyclic graphs.*

A ranking on a graph is an assignment of positive integers to its vertices such that any path between two vertices of the same rank contains a vertex of strictly larger rank. The rank number of a graph is the fewest number of labels that can be used in a ranking. In this paper we determine rank numbers for cubic ladders, generalized ladder graphs and some trees and unicyclic graphs. (Received August 19, 2010)

1067-05-312 **Jesse Calvert***, Washington University - St. Louis, 1 Brookings Drive, St. Louis, MO 63130, and **Michael Schuster**, North Carolina State University, Raleigh, NC 27695. *The Computation of $R(K_5-P_3,K_5)=25$**

In 1989, Hendry compiled a table of Ramsey numbers $R(G,H)$ for connected graphs G and H on five vertices. For the Ramsey number $R(K_5-P_3,K_5)$ he lists the bound $R(K_5-P_3,K_5)\leq 28$; a lower bound is obtained from the well known result $R(K_4,K_5)=25$. In 2009, Black, Leven and Radziszowski showed that the upper bound can be further reduced to $R(K_5-P_3,K_5)\leq 26$.

Here we prove that $R(K_5-P_3,K_5)=25$ using computer algorithms, which solves one of the three remaining open cases in Hendry's table, leaving only $R(K_5,K_5)$ and $R(K_5,K_5-e)$ unknown. In addition, we show that there are no (K_5-P_3,K_5)-good graphs containing a K_4 on 23 or 24 vertices. The unique (K_5-P_3,K_5)-good graph with a K_4 on 22 vertices is presented. Finally, we use a result by Burr, Erdös, Faudree and Schelp to show that $R(K_5-P_3,\widehat{K}_{5,2})=25$, where $\widehat{K}_{5,2}$ is the graph obtained by attaching a vertex to a K_5 using 2 edges. (Received August 19, 2010)

1067-05-314 **Joseph Kung*** (kung@unt.edu), Department of Mathematics, University of North Texas, Denton, TX 76203. *Parcels defined by congruence conditions and evaluations of the Tutte polynomial.* Preliminary report.

Let $M(G)$ be a matroid defined by linear dependence on the column vectors of a matrix G over the finite field GF(q). A flow is a vector in the row space of G. A parcel is a subset of pairs (f,g) of functions satisfying a coboundary condition, that the difference $f-g$ is a flow and a congruence condition, that the size of the supports of f and g satisfy some congruence condition. We will present several results of the form: a linear combination of sizes of parcels, with coefficients roots of unity, equals an evaluation of the Tutte polynomial of $M(G)$ at a real or complex point $(\lambda-1,x-1)$ on the hyperbola $(\lambda-1)(x-1)=q$. (Received August 19, 2010)

1067-05-315 **Colton Magnant*** (dr.colton.magnant@gmail.com), 858 Willivee Dr., Decatur, GA 30033. *Distributing vertices on a hamiltonian cycle.*

Within the last 10 years, much work has been done attempting to get specified vertices spread out around a hamiltonian cycle of a graph. Some desire simply to have space between the chosen vertices while others want the vertices in a particular order and would like to specify the distance between consecutive chosen vertices. In this talk, we will survey results in this area and present new results of this type. (Received August 19, 2010)

1067-05-333 **Eddie Cheng*** (echeng@oakland.edu), Department of Mathematics & Statistics, Oakland University, Rochester, MI 48309, and **Laszlo Liptak**, **Marc J Lipman**, **Philip Hu** and **Roger Jia**. *Matching preclusion and conditional matching preclusion problems for regular graphs.*

Let G be r-regular even graph. A matching preclusion set is a set of edges whose deletion results in a graph with no perfect matchings; the size of an optimal set is the matching preclusion number, $\text{mp}(G)$. If G is bipartite, then Hall's Theorem implies that $\text{mp}(G) = r$. Plesník proved that this is true in general if G is $(r-1)$-edge-connected. A trivial matching preclusion set is a set of edges incident to a single vertex v. G is super matched if every optimal matching preclusion set is trivial. A conditional matching preclusion set is a set of edges whose deletion results in a graph with no isolated vertices and no perfect matchings; the size of such an optimal set is the conditional matching preclusion number, $\text{mp}_1(G)$. A trivial conditional matching preclusion set can be constructed as follows: Take any 2-path $u - v - w$ and consider $\delta(u) \cup \delta(w) \setminus \{(u,v),(v,w)\}$. G is conditionally super matched if every optimal matching preclusion set is trivial. In this talk, we consider sufficient conditions that are in the same spirit as Plesník's Theorem for G to be super matched, for $\text{mp}_1(G)$ to attain the trivial upper bound, and for G to be conditionally super matched. (Received August 23, 2010)

1067-05-337 **Delong Meng*** (delong13@mit.edu), 290 Massachusetts Ave, Cambridge, MA 02139.
Reduced decompositions and permutation patterns generalized to the higher Bruhat order.

A reduced decomposition of $w \in S_n$ is an expression of w as a sequence of adjacent transpositions. For example, (12, 13, 23, 14, 24) is a reduced decomposition of 3421 because the squence of transpositions changes 1234 to 3421 as follow:

$$\mathbf{12}34 \to 2\mathbf{13}4 \to \mathbf{23}14 \to 32\mathbf{14} \to 3\mathbf{24}1 \to 3421.$$

The higher Bruhat is a family of posets, one of which is a partial order on the symmetric group. Even though other posets in the higher Bruhat order possess many properties intrinsically similar to the symmetric group, reduced decompositions have never been studied for those posets.

We generalize reduced decompositions to the higher Bruhat order, which in turn shed new light on the reduced decompositions for the symmetric group.

During our study, we introduce generalized permutation patterns into the pictures. Our main result is a geometric representation of reduced decompositions and permutation patterns of the higher Bruhat order as hyperplane arrangements, which yields a generalization of the freely braided permutations studied by Green and Losonczy and the tree graphs of commutation classes studied by Bridget Eileen Tenner. (Received August 24, 2010)

1067-05-345 **Jim Geelen** and **Stefan H.M. van Zwam*** (Stefan.van.Zwam@cwi.nl), P.O. Box 94079, NL-1090GB Amsterdam, Netherlands. *When the branch width is high...*

Like tree width in graphs, branch width is a central concept in matroid structure theory. When the branch width of the matroids in a class is low, questions surrounding well-quasi-ordering and efficiency of algorithms become more tractable. When the branch width of a matroid is high, different good things happen. For instance, the matroid will have the cycle matroid of a big grid as minor. We will look at another consequence of high branch width: an extension of the Splitter Theorem. (Received August 26, 2010)

1067-05-356 **Joseph E. Bonin*** (jbonin@gwu.edu), Department of Mathematics, The George Washington University, Washington, DC 20052, **Joseph P.S. Kung**, Department of Mathematics, University of North Texas, Denton, TX 76203, and **Anna de Mier**, Departament de Matematica Aplicada II, Universitat Politecnica de Catalunya, Barcelona, Spain. *Characterizations of fundamental transversal matroids.*

A result of Mason, with a simplification observed by Ingleton, characterizes transversal matroids as the matroids that satisfy a particular inequality that relates the ranks of intersections and unions of nonempty sets of cyclic flats. We show that fundamental transversal matroids are precisely the matroids that yield equality in Mason's inequality. We also deduce a characterization of fundamental transversal matroids due to Brylawski from our simpler result. (Received August 26, 2010)

1067-05-359 **Eva K. Belmont*** (ebelmont@fas.harvard.edu), Department of Mathematics, FAS, Harvard University, 1 Oxford St., Cambridge, MA 02138. *Paths as m-step Competition Graphs.*

For any digraph D let the m-step competition graph $C^m(D)$ be the graph with the same vertices as D, where x and y are connected in $C^m(D)$ if there are m-step paths in D from x and y to a common vertex z. G.T. Helleloid (2005) showed that if $m \geq n$, then the path P_n on n vertices is not an m-step competition graph for any digraph D. J. Kuhl and B.C. Swan (2010) showed that P_n is not an m-step competition graph for $\frac{n}{2} \leq m \leq n-3$, and that P_n is an m-step competition graph if either $m|n-1$ or $m|n-2$. We show that these conditions are necessary; that is, P_n is an m-step competition graph if and only if the aforementioned divisibility conditions hold. (Received August 26, 2010)

1067-05-369 **J. W. Estes*** (jwestes@olemiss.edu), 5 CR 236, Oxford, MS 38610, and **William Staton**. *Diatonic Graphs.* Preliminary report.

It has been known for at least 2500 years that mathematics and music are directly related. This article explains and extends ideas originating with Euler involving labeling parts of graphs with notes in such a way that other parts of the graphs correspond in a natural way to chords. The principal focus of this research is the notion of diatonic labelings of cubic graphs, that is, labeling the edges with pitch classes in such a way that vertices are incident with edges labeled with the pitch classes of a triad in a given diatonic scale. The pitch classes are represented in a natural way with elements of $\mathbb{Z}_{12}$, the integers modulo twelve.

Several classes of cubic graphs are investigated and shown to be diatonic. Among the graphs considered are Platonic Solids, cylinders, and Generalized Petersen Graphs. It is shown that there are diatonic cubic graphs on n vertices for even $n \geq 14$. Also it is shown that there are cubic graphs on n vertices that do not have diatonic labellings for all even $n \geq 4$. The question of forbidden subgraphs is investigated, and a forbidden subgraph for diatonic graphs, or "clash", is demonstrated. (Received September 06, 2010)

1067-05-377 **Eric L. Clark*** (eric.clark@uky.edu), 715 Patterson Office Tower, Department of Mathematics, University of Kentucky, Lexington, KY 40506-0027, and **Richard Ehrenborg**. *The excedance algebra.* Preliminary report.

Motivated by a result from Ehrenborg and Steingrímsson on the excedance set permutation statistic, let the Excedance Algebra be given by the ring $\mathbb{Z}\langle a, b\rangle$ of polynomials in the non-commuting variables a and b subject to the relation $ba - ab - a - b = 0$. Thus, any ab-word u can be rewritten as a sum of monomials of the form $a^i b^j$. In this talk, we will study the coefficients of these monomials which have many interesting interpretations, including Genocchi numbers, Gandhi polynomials, and elementary symmetric functions. (Received August 30, 2010)

1067-05-420 **Suil O*** (suilo2@math.uiuc.edu), 409 W. Green Street, Urbana, IL 61801, and **Douglas B West** and **Hehui Wu**. *Longest Cycles in k-connected Graphs with Given Independence Number.*

The Chvátal-Erdős Theorem states that every graph whose connectivity is at least its independence number has a spanning cycle. In 1976, Fouquet and Jolivet conjectured an extension: If G is an n-vertex k-connected graph with independence number a, and $a \geq k$, then G has a cycle with length at least $\frac{k(n+a-k)}{a}$. We prove this conjecture. (Received September 09, 2010)

1067-05-421 **Dinesh Sarvate***, Department of Mathematics, College of Charleston, Charleston, SC 29424, **V. Murali**, Dept. of Pure and Applied Math, Rhodes University, Grahamstown, South Africa, and **Hau Chan** (hchan@edisto.cofc.edu), Dept of Computer Science, Stony Brook, NY 11794. *Two new Graph factorization problems.* Preliminary report.

Recently two new types of designs have been introduced and studied. Sarvate and Hau Chan, obtained the existence results for the first type of designs for $t = 1$. These designs were introduced by Sarvate and William Beam. V. Murali and Sarvate introduced second type of designs, called Fuzzy designs. Both designs naturally lead to new types of graph factorizations. We will introduce the designs, present some existence results and discuss the corresponding graph factorization problems. (Received September 02, 2010)

1067-05-423 **Younjin Kim*** (ykim36@illinois.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61802, and **Zoltan Furedi** (z-furedi@math.uiuc.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61802. *Cycle-saturated graphs with minimum number of edges.*

A graph G is called F-saturated if it does not contain any copy of F, but for any edge e in the complement of G the graph $G + e$ contains some F. The minimum size of an n-vertex F-saturated graph is denoted by $sat(n, F)$.

We give almost exact asymptotics for $sat(n, C_k)$ as k is fixed and $n \to \infty$ where C_k is a cycle with length k. This is a joint work with Zoltán Füredi.
(Received September 22, 2010)

1067-05-440 **Drago Bokal**, **Bogdan Oporowski** and **R. Bruce Richter*** (brichter@uwaterloo.ca), Dept. of Combinatorics & Optimization, University of Waterloo, Waterloo, ON N2L 3G1, Canada, and **Gelasio Salazar**. *2-crossing-critical graphs.*

A graph G is k-crossing-critical if the crossing number $cr(G)$ is at least k, but, for every proper subgraph H of G, $cr(H) < k$. (We ignore vertices with degree 2, as they play no role in the crossing number of a graph.) From Kuratowski's Theorem, the only 1-crossing-critical graphs are the complete graph K_5 and the complete bipartite graph $K_{3,3}$.

In this project, we prove that if G is 3-connected, 2-crossing-critical, and has at least ten million vertices, then G has a very special, completely determined, circular structure. The proof shows that if G has a Möbius ladder V_{10} as a minor, then G has the structure. If G has no V_{10}-minor, then it has bounded size.

We know how to determine all the 3-connected, 2-crossing-critical graphs with no V_8-minor, so what remains to be determined is those with a V_8-minor but no V_{10}-minor. (Received September 03, 2010)

1067-05-536 **Hong-Jian Lai**, Department of Mathematics, 320 Armstrong Hall, P.O. Box 6310, Morgantown, WV 26506, **Yanting Liang*** (lyt814@math.wvu.edu), Department of Mathematics, 320 Armstrong Hall, P.O. Box 6310, Morgantown, WV 26506, and **Ping Li**. *Degree sequences and graphs with disjoint spanning trees.*

A non-increasing sequence $d = (d_1, d_2, \cdots, d_n)$ is graphic if there is a simple graph G with degree sequence d. In this paper, it is proved that for a positive integer k, a graphic sequence d has a simple realization G which has k-edge-disjoint spanning trees if and only if either both $n = 1$ and $d_1 = 1$, or $n \geq 2$ and both $d_n \geq k$ and $\sum_{i=1}^{n} d_i \geq 2k(n-1)$. (Received September 08, 2010)

1067-05-566 **Florian Block*** (blockf@umich.edu), University of Michigan, 530 Church St, Ann Arbor, MI 48109. *Computing Node Polynomials for Plane Curves.*

Enumeration of plane algebraic curves has a 150-year-old history. A combinatorial approach to this problem, inspired by tropical geometry, was recently suggested by Brugalle, Fomin, and Mikhalkin. I will explain this approach and its applications to computing Gromov-Witten invariants (or Severi degrees) of the complex projective plane, and their various generalizations.

According to Goettsche's conjecture (now a theorem), these invariants are given by polynomials in the degree d of the curves being counted, provided that d is sufficiently large. I will discuss how to compute these "node polynomials," and how large d needs to be. (Received September 09, 2010)

1067-05-587 **Neil Hindman*** (nhindman@aol.com). *Monochromatic sums equal to products in* $\mathbb{N}$.

Csikvári, Gyarmati, and Sárközy asked whether, whenever the set $\mathbb{N}$ of positive integers is finitely colored, there must exist monochromatic a, b, c, and d such that $a + b = cd$ and $a \neq b$. We provide an affirmative answer, establishing the following much stronger statement, (where FS and FP refer to "finite sums" and "finite products" respectively).

Theorem. *Let $m, r \in \mathbb{N}$ with $m > 1$ and let $\mathbb{N} = \bigcup_{k=1}^{r} A_k$. There exist $k \in \{1, 2, \ldots, r\}$, $d \in \mathbb{N}$, and sequences $\langle x_t\rangle_{t=1}^{m}$ and $\langle y_t\rangle_{t=1}^{m}$ such that*

(1) *$\langle x_t\rangle_{t=1}^{m}$ has distinct finite sums;*

(2) *$\langle y_t\rangle_{t=1}^{m}$ has distinct finite products;*

(3) *$\sum_{t=1}^{m} x_t = \prod_{t=1}^{m} y_t = d$;*

(4) *$FS(\langle x_t\rangle_{t=1}^{m}) \cup FP(\langle y_t\rangle_{t=1}^{m}) \subseteq A_k$; and*

(5) *$FS(\langle x_t\rangle_{t=1}^{m}) \cap FP(\langle y_t\rangle_{t=1}^{m}) = \{d\}$.*

(Received September 10, 2010)

1067-05-591 **Hannah Alpert*** (hcalpert@uchicago.edu), **Amariah Becker**, **James Hilbert**, **Jennifer Iglesias** and **Garth Isaak**. *Edge switching on colored degree sequences.*

The colored degree sequence of an edge-colored graph gives the number of edges of each color incident to each vertex. We use edge switching to characterize the colored degree sequences of forests and the two-color degree sequences in which each vertex has the same degree in both colors. (Received September 10, 2010)

1067-05-607 **Mohit Kumbhat*** (kumbhat2@illinois.edu), Urbana, IL 61801, **A Kostochka** (kostochk@math.uiuc.edu), Urbana, IL 61801, and **T Luczak** (tomasz@mathcs.emory.edu), Atlanta, GA 30322. *Conflict free coloring of (simple) hypergraphs with few edges.*

A coloring of the vertices of a hypergraph $\mathcal{H}$ is called *conflict free* if each edge e of $\mathcal{H}$ contains a vertex whose color does not get repeated in e. The smallest number of colors required for such a coloring is called the conflict-free chromatic number of $\mathcal{H}$, and is denoted by $\chi_{CF}(\mathcal{H})$. Pach and Tardos studied this parameter for graphs and hypergraphs. Among other things, they proved that for an $(2r-1)$-uniform hypergraph $\mathcal{H}$ with m edges, $\chi_{CF}(\mathcal{H})$ is of the order of $m^{1/r}\log m$. They also raised the question whether the same result holds for r-uniform hypergraphs. In this talk we shall show that this is not necessarily true. Moreover, we provide lower and upper bounds on the minimum number of edges of an r-uniform simple hypergraph which is not conflict free k-colorable. This is a joint work with A. Kostochka and T. Łuczak. (Received September 10, 2010)

1067-05-615 **Hannah Alpert**, **Amariah Becker**, **James Hilbert** and **Jennifer Iglesias*** (jiglesias@hmc.edu), 340 E Foothill Blvd, Claremont, CA 91711, and **Garth Issak**. *A Variation on Kundu's Theorem.*

A score sequence for a tournament is a list of the total wins for each team. In 1953, Landau gave a necessary and sufficient condition for when the sequence is a valid score sequence for a round robin tournament (every team plays every other team once). This problem has remained unsolved if ties are allowed. We will consider the score sequence to be a list of triples in this case, where each triple tells how many wins, losses and ties each team has. In this talk we will present necessary and sufficient conditions for when a score sequence can be a valid sequence for a round robin tournament where each team has k or k + 1 ties. (Received September 11, 2010)

1067-05-643 **David G. Wagner*** (dgwagner@math.uwaterloo.ca), Department of C&O, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada. *Quaternionic unimodular matroids.*

I will sketch a proof that quaternionic unimodular matroids have the half-plane property, and tell what I know of the excluded minors for this class. (Received September 12, 2010)

1067-05-646 **Daniel Pragel*** (dpragel@uafortsmith.edu), 5210 Grand Avenue, Fort Smith, AR 72913-3649. *Algebraic and Graph-Theoretic Properties of the Box Product of Two Paths.*

The box product of graphs G and H is the graph with vertex set $G \times H$ such that $(i,j) \sim (i',j')$ if and only if either $i = i'$ and $j \sim j'$ in H, or $j = j'$ and $i \sim i'$ in G. We look at various properties of the graph formed by taking the box product of two paths, such as the determinant of its adjacency matrix and its possible endomorphisms. (Received September 12, 2010)

1067-05-687 **Carl R Yerger*** (cayerger@davidson.edu), Davidson College, Department of Mathematics, Davidson, NC 28035, and **Robin Thomas** (thomas@math.gatech.edu). *Steinberg's Conjecture on Higher Surfaces.*

In this talk, we will describe work related to a conjecture of Steinberg, which states that if a planar graph excludes 4-cycles and 5-cycles, then it is 3-colorable. Our work aims to give baseline results for graphs on higher surfaces. In particular, we show that if G is drawn in surface Σ, is 4-critical and has no cycles of length four through ten, then $|V(G)| \leq cg(\Sigma)$, where c is an explicit constant that comes out of the proof. This is joint work with Robin Thomas. (Received September 13, 2010)

1067-05-688 **David L. Clampitt*** (clampitt.4@osu.edu). *The Coin Problem, Central Words, and Guido of Arezzo.*

The classical coin problem asks which integer values $n \geq 0$ are representable with coins of denominations p and q, where $\gcd(p,q) = 1$. The greatest integer not representable (the Frobenius number) is $pq - (p+q)$, so the $p+q-1$ integers from $(p-1)(q-1)$ to $pq-1$ are representable. In a recent paper, Paquin and Reutenauer revisit the coin problem in relation to Christoffel words. The Christoffel word of length $p+q$ on the alphabet $A = \{a,b\}$ has the structure aub, where u is a central word, the unique palindrome with periods p and q (i.e., if $u = u_1 \cdots u_{p+q-2}$, then $u_k = u_{k+p}$ for $1 \leq k < q-2$ and $u_k = u_{k+q}$ for $1 \leq k < p-2$). In this paper, it is shown that u is encoded by the $p+q-2$ differences in $Zp \times Zq$ between solutions to adjacent values n and $n+1$, $pq-(p+q) < n < pq-1$. Central words also encode constructions by the 11th-century music theorist, Guido of Arezzo: his hexachord, and the diamond diagram from his treatise, Micrologus. In these cases, the values p and q represent the generic lengths (spans) of perfect fourths (3) and fifths (4), and perfect fifths (4) and octaves (7), respectively. The conjunction of these facts is asserted to be productive on the music-theoretical side. (Received September 13, 2010)

1067-05-703 **Naomi T. Cameron*** (ncameron@lclark.edu), Department of Mathematical Sciences, Lewis & Clark College, 0615 SW Palatine Hill Road, Portland, OR 97219. *The Probability of an Even Number of Hills among Generalized Dyck Paths.* Preliminary report.

This investigation produces the asymptotic proportion of Dyck paths having an even number of hills. It also produces an analogous result for a generalization of Dyck paths, referred to here as ternary paths, which start at $(0,0)$, end at $(3n,0)$, use steps $(1,1)$ and $(1,-2)$ and never go below the x-axis. In the process, an analogue of the Fine number generating function is considered and certain relationships between Catalan and Fine generating functions are extended to the setting of this analogue. (Received September 13, 2010)

1067-05-704 **Amariah D. Becker*** (beckera@carleton.edu), **Hannah Alpert**, **James Hilbert** and **Jenny Iglesias**. *"Graphic" Degree Sequences for Edge-Colored Graphs.*

The degree sequence for an edge-colored graph on m vertices using n colors is a list of m n-tuples, in which each n-tuple corresponds to a vertex and specifies the degree of each color at that vertex. We explore under what conditions there exists a simple graph that satisfies a given such degree sequence. When such a graph exists we say that the degree sequence is 'graphic.' In particular, we examine graphs in which the maximum degree, Δ, is small, and we also show that for a fixed maximum degree and number of edge colors, we can decide in polynomial time whether a degree sequence is 'graphic.' (Received September 13, 2010)

1067-05-718 **Deborah A Chun*** (dchun@math.lsu.edu), 193 Ocean Dr, Baton Rouge, LA 70806. *Unavoidable Minors of 3-Connected Matroids.* Preliminary report.

Let M be a 3-connected matroid. Ding, Oporowski, Oxley, and Vertigan proved that if M has a huge number of elements, then M contains a large minor isomorphic to a line or its dual, a wheel, a whirl, a spike, or the cycle or bond matroid of a $K_{3,n}$ graph. We will discuss results related to and extending this theorem. (Received September 14, 2010)

1067-05-787 **Mark MacLean*** (macleanm@seattleu.edu), Seattle University, Math Department, Seattle, WA 98122, and **Paul Terwilliger**. *An A-invariant subspace for taut distance-regular graphs.* Preliminary report.

Let Γ denote a taut bipartite distance-regular graph with vertex set X, diameter $D \geq 4$, valency $k \geq 3$, and adjacency matrix A. We find a subspace W of $\mathbb{R}^X$ that is invariant under multiplication by A. The A-invariance of this particular subspace ties together an algebraically defined object (the taut distance-regular graph) and a combinatorial condition. Furthermore, our results demonstrate similarities between the taut distance-regular graphs and the well-studied 2-homogeneous distance-regular graphs. (Received September 14, 2010)

1067-05-790 **Amir Barghi*** (amir.barghi@dartmouth.edu) and **Peter Winkler**. *Firefighting on Random Geometric Graphs.* Preliminary report.

In the Firefighter Problem which was first introduced by Hartnell [1] in 1995, a fire starts at a vertex of a graph and in discrete time intervals spreads from burned vertices to their neighbors, unless they are protected by one of the f firefighters that are deployed every turn. Once protected, a vertex remains protected. We assume that the trees in a forest are randomly distributed with a fixed density and fire spreads from one tree to another if their distance is less than one. In this talk, we will discuss a technique from percolation that helps us prove that stopping the fire from spreading indefinitely, requires a linear relation between f and the density of the forest.

References

[1] B. L. Hartnell, *Firefighter! An Application of Domination*, presentation at the Twentieth Conference on Numerical Mathematics and Computing, University of Manitoba, 1995.

(Received September 14, 2010)

1067-05-792 **Jonathan Wild*** (wild@music.mcgill.ca), Schulich School of Music, McGill University, 555 Sherbrooke Ouest, Montreal, Quebec H2L 4H1, Canada. *Massively all-interval voice-leading structures.*

In this talk I present a remarkable voice-leading structure in nineteen-tone equal temperament ("19-tet"– equivalent to a historical meantone tuning where the perfect fifth is tempered by a third of a syntonic comma). At the core of the structure is the (19,9,4) Hadamard-Paley difference set, whose members are the quadratic residues mod 19: {1,4,5,6,7,9,11,16,17}. Each of the nine interval-classes (unordered distances) of 19-tet is found exactly four times among the members of this nine-note collection. The massively all-interval structure of the title is a voice-leading progression through a cycle of nine transpositions of this chord, joined in such a way that each transition between chords involves the nine voices moving by nine different interval-classes, and no single voice repeats any interval-class during the nine-chord cycle. A computer search has provided the solution to this problem; it is unique up to global pitch-class transposition/inversion and retrogression/circular permutation of the chord progression. Unexpected properties, both algebraic and musical, emerge from the various combinations of the nine voice-leading strands thus constructed. (Received September 14, 2010)

1067-05-801 **Min Yan*** (mamyan@ust.hk), Hong Kong Univ of Sci and Tech, Hong Kong, **Honghao Gao**, Hong Kong Univ of Sci and Tech, and **Nan Shi**, Hong Kong Univ of Sci and Tech. *Spherical Tiling by 12 Congruent Pentagons.*

The edge-to-edge tiling of the 2-dimensional sphere by congruent pentagons must contain at least 12 tiles. We give almost complete classification of the minimal tiling by 12 congruent pentagons, with the only unsolved problem being some very specific spherical geometrical problem. This is done by first separately classifying the combinatorial, edge length, and angle aspects of the tiling, and then combining the respective classifications together. (Received September 14, 2010)

1067-05-805 **Ryan K Therkelsen*** (rtherkelsen@bellarmine.edu), Mathematics Department, Bellarmine University, 2001 Newburg Road, Louisville, KY 40205. *Order in the Conjugacy Decomposition of the Rook Monoid.* Preliminary report.

The rook monoid R_n consists of the $(0,1)$-matrices of size n, having at most one non-zero entry in each row and each column. The Gauss-Jordan elements $\mathcal{GJ}$ of R_n are those elements in reduced row echelon form. Our object of study is the partially ordered set $\mathcal{P}$ whose elements are the conjugacy classes of $\mathcal{GJ}$ with a partial order defined in terms of a generalized dominance order on partitions of m, for $0 \le m \le n$. We present a new decomposition of $\mathcal{P}$, in terms of partitions, that we use to describe an order-preserving map between elements in $\mathcal{P}$ whose representatives have different rank. Analogous maps have been found for R_n that provide insight into its structure, under the Bruhat-Chevalley order. Time permitting, we will comment on how $\mathcal{P}$ fits in with a decomposition of $M_n(k)$ related to conjugacy classes. (Received September 15, 2010)

1067-05-846 **Maria Angelica Cueto**, **Enrique A. Tobis** and **Josephine Yu***, Georgia Tech, School of Mathematics, 686 Cherry St, Atlanta, GA 30332. *An Implicitization Challenge for Binary Factor Analysis.*

We use tropical geometry to compute the multidegree and Newton polytope of the hypersurface of a statistical model with two hidden and four observed binary random variables, solving an open question stated by Drton, Sturmfels and Sullivant in their book *Lectures on Algebraic Statistics* (Problem 7.7). The model is obtained from the undirected graphical model of the complete bipartite graph $K_{2,4}$ by marginalizing two of the six binary random variables. We present algorithms for computing the Newton polytope of its defining equation by parallel walks along the polytope and its normal fan. In this way we compute vertices of the polytope. Finally, we also compute and certify its facets by studying tangent cones of the polytope at the symmetry classes vertices. The Newton polytope has 17214912 vertices in 44938 symmetry classes and 70646 facets in 246 symmetry classes.
(Received September 15, 2010)

1067-05-850 **Ralph P. Grimaldi*** (ralph.grimaldi@rose-hulman.edu), Mathematics Department, Rose-Hulman Institute of Technology, 5500 Wabash Avenue, Terre Haute, IN 47803. *Extraordinary Subsets of* $1, 2, 3, \ldots, n$.

For $n > 0$ let $[n] = 1, 2, 3, \ldots, n$. A subset S of $[n]$ is called extraordinary if the size of S equals the minimal element in S. The number of extraordinary subsets of $[n]$ is F_n, the nth Fibonacci number. For these subsets, one can count (i) the total number of elements, with repeats considered, that appear in all the extraordinary subsets of $[n]$, and (ii) the sum of all the elements that appear among the extraordinary subsets. Fixing $n > 0$, for $1 \le k \le n$, we consider $a(n,k)$ which counts the number of extraordinary subsets of $[n]$ that contain k. We find that the sequence $a(n,k)$ is unimodal and discover the Catalan numbers when studying these unimodal sequences. (Received September 15, 2010)

1067-05-872 **Fan Wei*** (fan_wei@mit.edu), 6-301, 471 Memorial Drive, Cambridge, MA 02139. *The Weak Bruhat Order and Separable Permutations.*

Let $\mathfrak{S}_n$ denote the symmetric group of all permutations of $1, 2, \ldots n$, partially ordered by the weak Bruhat order. Thus for any permutation $w \in \mathfrak{S}_n$, the rank $\ell(w)$ of w is the number of inversions in w. It follows that the rank-generating function of $\mathfrak{S}_n$ is

$$F(\mathfrak{S}_n, q) = \sum_{w \in \mathfrak{S}_n} q^{\ell(w)} = (n)!,$$

where $(n) = (1)(2)\cdots(n)$ and $(i) = 1 + q + q^2 + \cdots + q^{i-1}$.

For any $w \in \mathfrak{S}_n$, we define two graded posets associated with w: $\Lambda_w = \{v \in \mathfrak{S}_n : v \le w\}$ and $V_w = \{v \in \mathfrak{S}_n : v \ge w\}$. In V_w, we define the rank of v to be $\ell(v) - \ell(w)$. We will show that if w is separable (i.e., 3142

and 2413-avoiding), then there is the surprising formula

$$F(\Lambda_w, q)F(V_w, q) = (n)!.$$

Moreover, we define a bijection $\varphi\colon \Lambda_w \times V_w \to \mathfrak{S}_n$ satisfying $\ell(u) + \ell(v) - \ell(w) = \ell(\varphi(u, v))$, and we give an explicit formula for $F(\Lambda_w, q)$ and $F(V_w, q)$. We also show that Λ_w and V_w are rank-symmetric and rank-unimodal for any separable permutation w.

These results were obtained under the supervision of Richard Stanley when the author was an undergraduate at MIT. (Received September 15, 2010)

1067-05-885 **Nicholas M Ercolani*** (`ercolani@math.arizona.edu`), Department of Mathematics, University of Arizona, 617 N. Santa Rita Ave. P.O. Box 210089, Tucson, AZ 85721-0089. *Cluster Expansions, Caustics and Counting Graphs.*

The main result to be described in this talk is the derivation of universal formulas for the generating functions (that enumerate graphs on Riemann surfaces – g-maps) appearing as coefficients of the large N genus expansion for the free energy of unitary ensembles of Hermetian random matrices. Time permitting we will also describe applications of these results which include new information about the double scaling limit of the free energy for these ensembles and the asymptotics of generating functions for graphical enumeration. (Received September 16, 2010)

1067-05-903 **Paul Wrayno*** (`pwrayno@emory.edu`), Dept. of Mathematics and CS, Emory University, 400 Dowman Dr., W401, Atlanta, GA 30322, and **Ronald J. Gould**. *Edges in 2-factor Isomorphic Graphs.*

A graph G is considered 2-factor isomorphic if it contains a 2-factor F, and all other 2-factors are isomorphic to F. Alternatively, when a 2-factor is viewed as a multiset of unlabeled cycles, copies of F are the only 2-factors in G. Faudree, Gould, and Jacobson give a formula and a construction for the maximum number of edges for 2-factor hamiltonian graphs as a function of $|V(G)|$. In this talk we will generalize this result to any chosen 2-factor, any 2-factor with a fixed number of cycles, and any unspecified 2-factor. Constructions of graphs that attain these bounds will also be given. (Received September 16, 2010)

1067-05-904 **F. Blanchet-Sadri** and **Laure Flapan*** (`laure.flapan@yale.edu`), PO Box 203164, New Haven, CT 06520, and **Stephen Watkins**. *Minimum Number of Holes in Unavoidable Sets of Partial Words.* Preliminary report.

Partial words are sequences over a finite alphabet that may have some undefined positions called holes. A set X of partial words over an alphabet A is called unavoidable if every two-sided infinite word over A has a factor compatible with a member of X. In this paper, we consider unavoidable sets of partial words of uniform length over an alphabet of any fixed size. We investigate the minimum number of holes in such sets. (Received September 16, 2010)

1067-05-914 **RJ Dolbin*** (`rj.dolbin@pepperdine.edu`), 24255 Pacific Coast Highway, Malibu, CA 90263. *Partitions, Young diagrams and ballot numbers.*

In this talk I will discuss a generalization of results from a paper with Bennett, Chari and Manning. I will define an algorithm which associates to an arbitrary partition a certain subset of all partitions, and show that applying the algorithm ℓ times gives rise to a set whose cardinality is either a ballot number (the self dual case) or twice that ballot number. What makes this process interesting is the presence of an involution τ which arises naturally in our context, but does not translate nicely or naturally to other ballot-number-enumerating contexts, such as modified Dyck paths. (Received September 16, 2010)

1067-05-917 **Stephen G Hartke** and **Derrick Stolee*** (`s-dstolee1@math.unl.edu`), P.O. Box 880130, Lincoln, NE 68588-0130, and **Douglas B West** and **Matthew Yancey**. *On extremal graphs with a given number of perfect matchings.* Preliminary report.

We consider the problem of maximizing the number of edges in a graph G on n vertices under the restriction that the number of perfect matchings in G is a given constant p. Dudek and Schmitt showed that this number approaches $\frac{n^2}{4} + c_p$ as n grows, where c_p is a constant depending only on p. This work extends the understanding of the sequence c_p, including some constructive lower bounds and a conjecture on its exact value. Moreover, we present some structural results on graphs which achieve the extremal number of edges. (Received September 16, 2010)

1067-05-920 **Don Wagner*** (don.wagner@navy.mil), 875 N. Randolph Street, Arlington, VA 22203. *Delta-Wye Reduction of Almost-Planar Graphs.*

A non-planar graph G is *almost planar* if, for every edge of G, either its deletion or contraction produces a planar graph. Evidently, both K_5 and $K_{3,3}$ are almost planar. It is shown that for any almost-planar graph G, there exists sequence of almost-planar graphs, starting with G and ending with $K_{3,3}$, such that each graph in the sequence is obtained from its predecessor by a series reduction, a parallel reduction, or a delta-wye exchange. Analogous results for other classes of graphs and matroids are considered (Received September 16, 2010)

1067-05-926 **Peter Nelson*** (apnelson@uwaterloo.ca) and **Jim Geelen**. *Growth rates in minor-closed classes of matroids.*

It is a well-known result of Mader that in any proper minor-closed class of graphs, the number of edges of a simple graph in the class is bounded by a linear function in its number of vertices, where the function depends only on the class itself. Analogous questions can be asked about the density of matroids in a minor-closed class.

Work of Geelen, Kabell, Kung and Whittle has yielded the 'Growth Rate Theorem', which gives a elegant description of the possible growth rates of minor-closed classes of matroids not containing arbitrarily long lines, dividing the classes into those that are linearly, quadratically and exponentially dense.

I will discuss the extension of the ideas in this theorem to the more general notion of minor-closed classes not containing arbitrarily large uniform matroids of a fixed rank, focusing on the linear and exponential cases. (Received September 16, 2010)

1067-05-957 **James Michael Shook*** (shookjm@gmail.com), CA , and **Bing Wei**. *A Characterization of the Centers of Chordal Graphs.*

A graph is chordal if it does not have an induced cycle with length greater than three. The distance $d(x, y)$ is the length of the shortest path from x to y. The eccentricity of a vertex x in a graph G is $\epsilon(x) = max\{d(x, y)|y \in V(G)\}$, and its radius and diameter are defined respectively as $Rad(G) = min\{\epsilon(x)|x \in V(G)\}$ and $Diam(G) = max\{\epsilon(x)|x \in V(G)\}$. The graph induced by the set of vertices of G with eccentricity equal to the radius is called the center of G. In this talk we will present a short and simple characterization of the centers of chordal graphs. (Received September 16, 2010)

1067-05-963 **Art Duval*** (artduval@math.utep.edu), University of Texas at El Paso, Department of Mathematical Sciences, 500 W. University Ave., El Paso, TX 79968-0514, and **Caroline Klivans** and **Jeremy Martin**. *The G-Shi arrangement, and its relation to G-parking functions.*

Pak and Stanley found a bijection between parking functions on $[n]$ and regions of the complement of the Shi arrangement, $\{x_i - x_j = 0, 1 \colon 1 \le i < j \le n\}$. In particular, there is a somewhat natural labeling of the regions such that every region has a different label, and these labels are precisely the parking functions on $[n]$.

We now define a G-Shi hyperplane arrangement

$$\{x_i - x_j = 0, 1 \colon 1 \le i < j \le n;\ \{i, j\} \text{ is an edge of } G\}$$

of an arbitrary graph G, and compare the regions of the complement of this arrangement to G-parking functions, a well-studied generalization of parking functions to arbitrary graphs. In particular, while the Pak-Stanley labels of regions are no longer necessarily unique, we conjecture that the set of different Pak-Stanley labels of regions of the G-Shi arrangement is precisely the set of $(G + v)$-parking functions, where $G + v$ is the join of G with a single vertex v. We offer some evidence in favor of the conjecture, including a proof that every label is a parking function. (Received September 16, 2010)

1067-05-964 **Nicholas George Triantafillou*** (ngtriant@umich.edu) and **Katie R. Banks** (krbanks@fas.harvard.edu). *Omnimosaics.* Preliminary report.

An omnimosaic $O(n, k, a)$, is defined to be an $n \times n$ matrix, with entries from the set $A = \{1, 2, ..., a\}$, that contains, as a submatrix, each of the a^{k^2} $k \times k$ matrices over A. We present a general scheme for the explicit construction of omnimosaics which yields square omnimosaics with $n \approx ka^{k/2}$. Time permitting, we will outline techniques used to compute $\omega(k, a)$ for small k and a, comment on higher-dimensional generalizations, and show that for fixed k and a the smallest possible size $\omega(k, a)$ of an $O(n, k, a)$ omnimosaic satisfies

$$\frac{ka^{k/2}}{e} \le \omega(k, a) \le \frac{ka^{k/2}}{e}(1 + o(1))$$

for a well-specified function $o(1)$ that tends to zero as $k \to \infty$. (Received September 17, 2010)

1067-05-969 **Jason D Yust*** (jason.yust@gmail.com), 11 Country Club Circle, Tuscaloosa, AL 35401. *The Mathematics of Contrapuntal Hierarchy in Music.*

The work of Heinrich Schenker (1868-1935) describes the hierarchic organization of tonal harmony in eighteenth and nineteenth century music. A class of networks called maximal outerplanar graphs (MOPs) or triangulations of the n-gon, combinatorially equivalent to binary plane trees, accurately describes many forms of musical hierarchy, including simplest structures of Schenkerian theory. But they do not suffice for complete analyses because they do not account for the most basic aspect of counterpoint, the possibility of simultaneous semi-independent activity in multiple voices. Schenker's own concept of counterpoint is unique because his theory requires that musical intervals be considered melodic and harmonic at the same time (according to the principles of unfolding and linear progression). Schenker's theory therefore implies a new form of "contrapuntal hierarchy" which can be represented by an expanded class of networks: 2-trees. 2-trees are closely related to MOPs, so we can draw on the geometry of simple hierarchy, the Stasheff polytope or associahedron, to describe the relationships between different contrapuntal hierarchies. Examples from J.S. Bach's Partitias illustrate contrapuntal hierarchies in music analysis. (Received September 18, 2010)

1067-05-980 **Matthew D Zeckner*** (Matthew.Zeckner@uky.edu), 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506, and **Benjamin J Braun**. *Deformation Retracts of Neighborhood Complexes of Stable Kneser Graphs.* Preliminary report.

Anders Björner and Mark de Longueville proved in 2001 that the neighborhood complex of any stable Kneser graph is homotopy equivalent to a sphere. They further conjectured that every such neighborhood complex contains a polytopal sphere as a deformation retract and proved this in special cases. We give an outline of the proof of their conjecture for other special cases. (Received September 20, 2010)

1067-05-1008 **Alexandra Ovetsky Fradkin*** (aovetsky@math.princeton.edu), Fine Hall, Washington Rd, Princeton, NJ 08544, and **Paul D. Seymour** (pds@math.princeton.edu), Fine Hall, Washington Rd, Princeton, NJ 08544. *Immersion in digraphs and related problems.* Preliminary report.

A digraph H is *immersed* in a digraph G if the vertices of H are mapped to the vertices of G, and the edges of H are mapped to edge-disjoint (directed) paths of G. Consider the following algorithmic problem for a fixed (di)graph H:

Input: (di)graph G
Question: Is H immersed in G?

This problem is polynomial-time solvable in undirected graphs for all H, whereas in digraphs the problem is sometime polynomial-time solvable and sometimes NP-complete, depending on the digraph H. We will discuss some progress made towards classifying digraphs into these two classes. We will also show that the problem becomes polynomial-time solvable for all H once you restrict to digraphs with bounded independence number.

One problem closely related to immersion is the k edge-disjoint paths problem. For fixed k, this can be solved in polynomial time in undirected graphs and is NP-complete in digraphs even when $k = 2$. However, just as with immersion, we will show that the problem becomes polynomial-time solvable for all fixed k once you restrict to digraphs with bounded independence number. (Received September 17, 2010)

1067-05-1010 **Craig Eric Larson*** (clarson@vcu.edu), Dept of Mathematics and Applied Mathematics, 4106 Grace E. Harris Hall, 1015 Floyd, Richmond, TX 23220, and **Ryan Pepper**. *The Independence and Annihilation Numbers.*

The *annihilation number* A of a graph is a polynomial-time computable upper bound of the independence number α of a graph. Given the degree sequence of a graph in non-decreasing order, A is the largest index such that the sum of the first A degrees is no more than the sum of the remaining degrees. We present here a characterization of graphs with equal independence and annihilation numbers, together with a polynomial-time algorithm for determining if a graph has this property. (Received September 17, 2010)

1067-05-1043 **Maxim J. Goldberg** (mgoldber@ramapo.edu), Ramapo College of NJ, TAS, 505 Ramapo Valley Road, Mahwah, NJ 07430, and **Seonja Kim*** (skim4@sunyrockland.edu), SUNY Rockland Community College, 145 College Road, Suffern, NY 10901. *An efficient tree-based computation of a natural diffusion distance.*

Using diffusion to define distances between points on a manifold (or a sampled data set) has been successfully employed in various applications such as data organization and approximately isometric embedding of high dimensional data in low dimensional Euclidean space. Recently, P. Jones has proposed a diffusion distance (symmetric, but not satisfying the triangle inequality) which is both intuitively appealing and scales appropriately with increasing time. Roughly, his proposal is to define the distance between two points as the first *time* that the diffusion densities "spreading" from the points overlap sufficiently. We present an efficient tree-based approach to computing an approximation to Jones' diffusion distance. We also illustrate that our approximation is comparable to Jones' proposal.

One can then apply a general construction to obtain an "almost" metric from a general distance (we presented this construction at the Joint Meetings in San Francisco in 2010). (Received September 18, 2010)

1067-05-1045 **Xujin Chen**, **Guoli Ding*** (ding@math.lsu.edu), **Xiaodong Hu** and **Wenan Zang**. *The Maximum-weight Stable Matching Problem.*

Given a preference system $(G, \prec)$ and an integral weight function defined on the edge set of G (not necessarily bipartite), the maximum-weight stable matching problem is to find a stable matching of $(G, \prec)$ with maximum total weight. In this talk we consider this NP-hard problem using linear programming and polyhedral approaches. We show that the Rothblum system for defining the fractional stable matching polytope of $(G, \prec)$ is totally dual integral if and only if this polytope is integral if and only if $(G, \prec)$ contains no so-called semistable partitions with odd cycles. We also present a combinatorial polynomial-time algorithm for the maximum-weight stable matching problem and its dual on any preference system containing no semistable partitions with odd cycles. Our results generalize Király and Pap's theorem on the maximum-weight stable-marriage problem and rely heavily on their work. (Received September 17, 2010)

1067-05-1055 **Michel X. Goemans*** (goemans@math.mit.edu), MIT, Room 2-351, 77 Massachusetts Ave., Cambridge, MA 02420. *Thin spanning trees, conductances, nowhere zero flows, and the traveling salesman problem.*

A spanning tree T in a graph G is ϵ-thin if T contains at most an ϵ fraction of the edges of every cut. Goddyn's conjecture says that every $f(\epsilon)$-edge-connected graph contains an ϵ-thin tree for a suitable function f. In this talk, we discuss this conjecture and variants of it, and its implications for nowhere zero 3-flows and for the approximability of the asymmetric traveling salesman problem. In particular, we show that, if the graph is $(c\log(n)/\log\log(n))$-edge-connected, one can select conductances in a corresponding electrical network so that a random spanning tree is ϵ-thin with high probability. We also show that, if we replace the spanning tree requirement by simply having a linear number of edges then Goddyn's conjecture can be proved. (Received September 17, 2010)

1067-05-1092 **Bertrand Guenin**, Dept. of Combinatorics and Optimization, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada, **Irene Pivotto***, Dept. of Combinatorics and Optimization, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada, and **Paul Wollan**, Dept. of Computer Science, University of Rome, La Sapienza, Via Salaria 113, 00198 Rome, Italy. *Non-degenerate even cycle matroids.*

A signed graph is a representation of an even cycle matroid M if the cycles of M correspond to the even cycles of the signed graph. Two signed graphs are equivalent if they are related by Whitney flips and signature exchanges. An even cycle matroid is degenerate if it is the projection of a graphic matroid. We show that an even cycle matroid which contains a non-degenerate fixed size minor has a bounded number of inequivalent representations. For instance, even cycle matroids which contain R_10 as a minor have at most six non-equivalent representations. If time permits we will also discuss a similar result for even cut matroids. (Received September 18, 2010)

1067-05-1104 **Antonio Blanca*** (ablanca3@gatech.edu), 4390 Iroquois Tr., Duluth, GA 30096. *On Universal Cycles for new Classes of Combinatorial Structures.* Preliminary report.

A universal cycle (u-cycle) is a compact listing of a collection of combinatorial objects. In this paper, we use natural encodings of these objects to show the existence of u-cycles for collections of subsets, matroids, restricted multisets, chains of subsets, multichains, and lattice paths. For subsets, we show that a u-cycle exists for the k-subsets of an n-set if we let k vary in a non zero length interval. We use this result to construct a "covering" of length $(1+o(1))\binom{n}{k}$ for all subsets of $[n]$ of size exactly k with a specific formula for the $o(1)$ term. We also show that u-cycles exist for all n-length words over some alphabet Σ, which contain all characters from $R \subset \Sigma$. Using this result we provide u-cycles for encodings of Sperner families of size 2 and proper chains of subsets. (Received September 18, 2010)

1067-05-1114 **Seog-Jin Kim**, **Alexandr V. Kostochka**, **Douglas B. West** and **Hehui Wu*** (hehuiwu2@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W Green Street, Urbana, IL 61801, and **Xuding Zhu**. *Decomposition of sparse graphs using forests and a graph with bounded degree.*

From the Matroid Union Theorem by Edmonds and Nash-Willams, the Tree Packing Theorem will immediately follow: a graph decomposes into k forests if and only if the arboricity $\max_{H\subseteq G}\lceil |E(H)|/(|V(H)|-1)\rceil$ is at most k. We consider the *fractional arboricity* $\max_{H\subseteq G}\frac{|E(H)|}{|V(H)|-1}$. The Nine Dragon Tree(NDT) Conjecture, posted by Montassier et al., states that if the fractional arboricity of a graph is at most $k+\frac{d}{k+d+1}$, then the graph decomposes into $k+1$ forests, with one of them having maximum degree at most d.

For $d \geq k+1$, we prove a sharp sparseness condition for decomposability into k forests and a graph having maximum degree at most d. Consequences are that every graph with fractional arboricity at most $k+d/(k+d+1)$ has such a decomposition. For $d \leq k+1$, we prove that every graph with fractional arboricity at most $k+d/(2k+2)$ decomposes into $k+1$ forests, with one of them having maximum degree at most d. This implies the NDT Conjecture for the case $d = k+1$. Also, for $k = 1$, we prove that the NDT Conjecture is true for $d \leq 6$. (Received September 19, 2010)

1067-05-1120 **Avraham Ben-Aroya** and **Amnon Ta-Shma***, amnon@tau.ac.il. *Constructing Small-Bias Sets from Algebraic-Geometric Codes.*

We give an explicit construction of an ϵ-biased set over k bits of size $O\left(\frac{k}{\epsilon^2\log(1/\epsilon)}\right)^{5/4}$. This improves upon previous explicit constructions when ϵ is roughly (ignoring logarithmic factors) in the range $[k^{-1.5}, k^{-0.5}]$. The construction builds on an algebraic-geometric code. However, unlike previous constructions we use low-degree divisors whose degree is significantly smaller than the genus. (Received September 19, 2010)

1067-05-1124 **Patricia L. Hersh*** (plhersh@ncsu.edu), Patricia Hersh, Box 8205, North Carolina State University, Raleigh, NC 27695-8205. *Interplay of Combinatorics and Topology through Posets.*

This talk will focus on how partially ordered sets help record topological structure, including mentioning some limitations in how much they can capture. I will briefly discuss my work on discrete Morse theory for order complexes of partially ordered sets and how this has been used e.g. to count by inclusion-exclusion. Then I'll turn things around and discuss more recent work on how topological structure of a stratified space can sometimes be gleaned from combinatorics of its closure poset combined with codimension one topology. This is used to show that certain stratified spaces arising from combinatorial representation theory are regular CW complexes homeomorphic to balls. Familiarity with this area will not be assumed. (Received September 19, 2010)

1067-05-1142 **Emily Hale-Sills***, Department of Mathematics and Statistics, Smith College, Northampton, MA 01063, and **Kim Lockrow**, **Emily Merrill** and **Samantha Lowe**. *Exponential Domination in Grid Graphs.* Preliminary report.

We consider a variation on the domination number of a graph. Let G be a graph, $S \subset V$ a subset of the vertices and $d(u,v)$ the distance between vertices u, v. Define

$$w_S(v) = \begin{cases} \sum 1/(2^{d(u,v)-1}) & \text{if } v \notin S, \\ 2, & \text{if } v \in S \end{cases}$$

S is an *exponential dominating set* if for all vertices v, $w_S(v) \geq 1$. The exponential dominating number, $\gamma_e(G)$ is the least number of vertices in an exponential dominating set. This idea was introduced in a recent paper of Dankelmann et al. Here we give results for the exponential dominating number for various classes of grid graphs. (Received September 19, 2010)

1067-05-1157 **Kiran Chilakamarri**, **Nathaniel Dean** and **Cong X Kang*** (kangc@tamug.edu), 200 Seawolf Parkway, Galveston, TX 77554, and **Eunjeong Yi**. *Iteration index of a zero forcing set in a graph.* Preliminary report.

Let each vertex of a graph $G = (V(G), E(G))$ be given one of two colors, say, "black" and "white". Let Z denote the (initial) set of black vertices of G. The *color-change rule* converts the color of a vertex from white to black if the white vertex is the only white neighbor of a black vertex. The set Z is said to be *a zero forcing set* of G if all vertices of G will be turned black after finitely many applications of the color-change rule. The *zero-forcing number* of G is the minimum of $|Z|$ over all zero forcing sets $Z \subseteq V(G)$. Zero forcing parameters have been studied and applied to the minimum rank problem for graphs in numerous articles. Now, define *the iteration index* of a zero forcing set of a graph G to be the number of (global) applications of the color change rule required to turn all vertices of G black. We will, in this talk, present some basic properties of the iteration index and discuss some preliminary results on certain graphs. (Received September 20, 2010)

1067-05-1175 **Evan M. O'Dorney*** (Emo916math@gmail.com), 119 Shelterwood Lane, Danville, CA 94506. *Permutation Puzzles.*

Define a *permutation puzzle* as a partition of $\{1, \ldots, n\}$ into blocks, a permutation cycle type that includes the block to which each element belongs, and a "rule" stipulating that the values of the permutation in each block are either ascending or descending. In 2009, J. Steinhardt proved that a such a puzzle has at most one solution. We investigate rules other than ascending and descending. We prove that the number of solutions to any puzzle with only one such rule has a bound depending only on that rule, and we give an algorithm for computing it. We prove that in the special case that all rules are ascending except one, which reverses the order of its first two elements, then the permutation puzzle has at most two solutions. We propose possible generalizations to other classes of rules. (Received September 19, 2010)

1067-05-1178 **F. Blanchet-Sadri**, **Kevin Black** and **Andrew Zemke*** (drew.zemke@gmail.com), School of Mathematical Sciences, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623-5603. *Minimum hole sparsity for partial word avoidability.*

A partial word is a sequence of symbols from a finite alphabet that may have some undefined positions, called holes, that match every letter of the alphabet. Previously, Blanchet-Sadri, Mercas, Simmons, and Weissenstein completed the classification of binary patterns with respect to partial word avoidability. We pose the problem of avoiding patterns in partial words that are very dense with holes. We define the concept of hole sparsity, a measure of the frequency of holes in a partial word. We also present two algorithms that can be used to show that a pattern is avoidable over an alphabet of a given size, allowing for partial words. Finally, we determine the minimum hole sparsity for all unary and some binary patterns in the context of trivial and nontrivial avoidability.
(Received September 19, 2010)

1067-05-1179 **Samantha Dahlberg**, **Timothy Ferdinands** and **Akalu Tefera*** (teferaa@gvsu.edu), Grand Valley State University, Department of Mathematics, Allendale, MI 49401. *A Wilf-Zeilberger Approach to Sums of Choi, Zornig and Rathie.*

In this talk we present elegant and elementary proofs of identities that involve sums of the type in the title using Zeilberger's algorithm and the Wilf-Zeilberger proof style. (Received September 19, 2010)

1067-05-1190 **Carolyn Chun*** (carolyn.chun@vuw.ac.nz), MSOR, PO Box 600, Wellington, 6140, and **Dillon Mayhew** (chchchun@gmail.com) and **James Oxley**. *Towards a splitter theorem for internally 4-connected binary matroids.* Preliminary report.

In 1980, Seymour proved that, for a 3-connected matroid M with a 3-connected proper minor N, there is an element e in $E(M)$ such that M/e or $M\backslash e$ is 3-connected and has a minor isomorphic to N unless N is a wheel or a whirl. This splitter theorem is an invaluable tool and we would like to obtain a corresponding result for internally 4-connected binary matroids. In this talk, we indicate how to construct all such matroids and we describe progress towards a splitter theorem for these matroids. (Received September 20, 2010)

1067-05-1196 **Lisa M Warshauer*** (wars@math.lsu.edu), LA. *Graphs that are Almost Series-Parallel.*

A graph is almost series-parallel if there is some edge that one can add to the graph and then contract out to leave a series-parallel graph. This class of graphs is closed under taking minors. We describe the structure of the members of this class and determine a sharp bound on the number of edges of a simple n-vertex member of the class. The main result of this talk gives the full list of excluded minors for the class of almost series-parallel graphs. (Received September 20, 2010)

1067-05-1205 **Zi-Xia Song***, Department of Mathematics, University of Central Florida, Orlando, FL 32816. *A Variation of the Classical Turán Type Problem.*

Let $D = (d_1, d_2, \ldots, d_n)$ be an integer sequence with $d_1 \geq d_2 \geq \cdots \geq d_n \geq 0$. We say that D is *graphic* if there is a graph G with D its degree sequence. In those circumstances, G is called a *realization* of D. We consider an extremal problem for graphs as introduced by Erdös, Jacobson and Lehel in 1991. That is to find the minimum even integer t such that every graphic sequence $D = (d_1, d_2, \ldots, d_n)$ with $\sum_{i=1}^{n} d_i$ at least t has a realization containing K_k as a subgraph. They conjectured that $t = (k-2)(2n-k+1)+2$. In this talk, we will survey the methods on solving this conjecture and recent results in this area on K_k-graphic sequences.
(Received September 20, 2010)

1067-05-1257 **Nantel Bergeron**, **Thomas Lam** and **Huilan Li*** (huilan.li@gmail.com), Department of Mathematics, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104. *Towers of Algebras, Combinatorial Hopf Algebras and Dual Graded Graphs.*

I will explain constructions which produce combinatorial Hopf algebras from towers of algebras, and dual graded graphs from Hopf algebras. These constructions are studied to show that towers of algebras $\oplus A_n$ which give rise to combinatorial Hopf algebras must have $\dim(A_n) = r^n n!$ where $r = dim(A_1)$. This is based on joint work with Bergeron and Lam. (Received September 20, 2010)

1067-05-1270 **Darren A. Narayan*** (dansma@rit.edu), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14623, and **Robert Jamison**. *Max-optimal and sum-optimal labelings of graphs.*

A k-ranking of a graph is a labeling of its vertices with k positive integers such that any path between two vertices with the same label contains a vertex with a larger label. A k-ranking is minimal if the reduction of any label greater than 1 violates the described ranking property. We consider two norms for minimal rankings. The max-optimal norm is the smallest k for which G has a minimal k-ranking. This value is also referred to as the rank number. In this talk we consider the sum-optimal norm in which the sum of all labels over all minimal rankings is minimized. We investigate similarities and differences between the two norms. In particular we show that sum-optimal rankings of paths and cycles are also max-optimal. (Received September 20, 2010)

1067-05-1272 **Mark Budden**, **Nicole Calkins** and **William Nathan Hack*** (nathan.hack@gmail.com), 102 Wyckfield Rd, Savannah, GA 31410, and **Joshua K Lambert** and **Kimberly Thompson**. *How large is your diameter? A quest for the diameter of a Rational Residue Graph.*

Paley graphs were first introduced by Sachs in the 1960's and has important connections with quadratic residues $(\mathbb{Z}/p\mathbb{Z})^{\times 2}$ where p is a prime and $p \equiv 1 \pmod 4$. A Paley graph G has p vertices and has an edge between two vertices a, b if $a - b$ is an element of $(\mathbb{Z}/p\mathbb{Z})^{\times 2}$. We can show Paley graphs have diameter 2, which follows from the relationship of quadratic residues. Taking this connection between quadratic residues and graphs we extended it to the world of rational residues for $p \equiv 1 \pmod{2^t}$. We give a sharp upper bounds for the diameter of rational residue graphs. Come and join us as we open your eyes to this new untamed frontier of combining Graph Theory and Number Theory. (Received September 20, 2010)

1067-05-1273 **Michael Ferrara*** (michael.ferrara@ucdenver.edu), **Ronald Gould**, **Michael Jacobson**, **Pfender Florian**, **Jeffrey Powell** and **Thor Whalen**. *New Ore-Type Conditions for H-Linked Graphs.*

A graph G is H-linked if any injective function $f : V(H) \to V(G)$ extends to an H-subdivision in G. The class of H-linked graphs extends the widely studied families of k-connected, k-linked and k-ordered graphs.

In this talk, we give sharp Ore-Type degree sum conditions that assure a sufficiently large graph G is H-linked for arbitrary H. These conditions extend and refine several known results on H-linked graphs, in particular a 2008 result of Kostochka and Yu that gives Ore-type conditions assuring a graph G is H-linked for *a*ll graphs H with a prescribed number of edges. (Received September 20, 2010)

1067-05-1274 **Karen A Yeats*** (karen_yeats@sfu.ca), Department of Mathematics, Simon Fraser University, 8888 University Dr., Burnaby, BC V5A 1S6, Canada. *Patterns in denominators of Feynman integrals.*

We now know of a number of identities of denominators of Feynman integrals after doing some (typically six) parametric integrations. I will present some of these identities from a combinatorial perspective, and discuss the connections they suggest to knot theory and matroids. (Received September 20, 2010)

1067-05-1293 **Ping Zhang*** (ping.zhang@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008. *Two Theorems on Four Colorings.*

A complete coloring of a graph G is a proper vertex coloring of G having the property that for every two distinct colors i and j used in the coloring, there are adjacent vertices colored i and j. The three parameters chromatic number, Grundy number and achromatic number of a graph G all arise from complete colorings of G. Three triples of positive integers which can be realized as the values of these three parameters of some graph are determined. The related question is answered when another coloring parameter called the irredundant chromatic number is added to these three. (Received September 20, 2010)

1067-05-1316 **Elliot J Krop*** (ElliotKrop@clayton.edu), Department of Mathematics, Clayton State University, 2000 Clayton State Blvd., Morrow, GA 30260, and **Irina Krop** (irina.krop@gmail.com), DePaul University, DePaul Center, 1E. Jackson, room 7122, Chicago, IL 60604. *Almost-rainbow edge-colorings of some small subgraphs.*

Let $f(n,p,q)$ be the minimum number of colors necessary to color the edges of K_n so that every K_p is at least q-colored. We improve current bounds on these nearly "anti-Ramsey" numbers, first studied by Erdős and Gyárfás. We show that $f(n,5,9) \geq \frac{7}{4}n - 3$, slightly improving the bound of Axenovich. We make small improvements on bounds of Erdős and Gyárfás by showing $\frac{5}{6}n + 1 \leq f(n,4,5)$ and for all even $n \not\equiv 1 \pmod 3$, $f(n,4,5) \leq n - 1$. For a complete bipartite graph $G = K_{n,n}$, we show an n-color construction to color the edges of G so that every $C_4 \subseteq G$ is colored by at least three colors. This improves the best known upper bound of M. Axenovich, Z. Füredi, and D. Mubayi. Keywords: Ramsey theory, generalized Ramsey theory, rainbow-coloring, edge-coloring, Erdős problem
(Received September 20, 2010)

1067-05-1338 **Ryan C Jones*** (r3jones1@wmich.edu), 1024 S. Park St., Apt. 2, Kalamazoo, MI 49001. *On Neighbor-Distinguishing Edge Colorings.*

We introduce a modular edge coloring of a graph, which gives rise to neighbor-distinguishing vertex colorings of the graph. We investigate the relationship between these colorings and proper vertex colorings. Some results and problems are presented. (Received September 20, 2010)

1067-05-1340 **Kyle Kolasinski*** (kyle.c.kolasinski@wmich.edu), 4435 Dover Hills Dr, Apt 203, Kalamazoo, MI. *On Hamiltonian-Colored Graphs.*

We introduce an edge coloring of a graph based on distances between verticies. From there, we study Hamiltonian properties of these distance-colored graphs.Results and problems are presented on this topic. (Received September 20, 2010)

1067-05-1351 **J Larry Langley*** (llangley@pacific.edu), Department of Mathematic, University of the Pacific, Stockton, CA 95211, and **K Sarah Merz**. *The Set Chromatic Number of a Directed Graph.* Preliminary report.

Chartrand, Okamoto, Rasmussen, and Zhang describe the set chromatic number as follows. Assign a color to each vertex. Adjacent vertices may have the same coloring. For the vertex v, consider the set of colors $NC(v)$ of the neighbors of v. A set coloring has $N(v) \neq N(u)$ for all pair of adjacent vertices u, v. The minimum number of such colors is the set chromatic number. We consider this definition generalized to directed graphs in two natural ways, by comparing outsets (equivalently insets) of adjacent vertices, and by comparing the outset of u to the inset of v when (u,v) is an arc in D. Unlike the usual definition of coloring, the set chromatic number may be different for directed graphs and their underlying graphs. (Received September 20, 2010)

1067-05-1359 **Hannah Alpert**, **Christina Koch** and **Joshua D Laison*** (jlaison@willamette.edu), Mathematics Department, Willamette University, 900 State St., Salem, OR 97301. *Obstacle Numbers of Graphs.*

An obstacle representation of a graph G is a drawing of G in the plane with straight line edges, together with a set of polygons called obstacles, such that an edge exists in G if and only if it does not intersect an obstacle. The obstacle number of G is the smallest number of obstacles in any obstacle representation of G. Although it seems that most graphs have obstacle number 1, we'll show that there exist graphs with arbitrarily large obstacle number. We'll also consider what happens if the obstacles are forced to be convex, and we'll present a number of open questions. This is work done in the Willamette Valley REU program. (Received September 20, 2010)

1067-05-1360 **Melanie Laffin*** (melanie.laffin@gmail.com), 1400 Townsend Dr., Houghton, MI 49931, and **Melissa Keranen** (msjukuri@mtu.edu). *Group Divisible Designs with Fixed Block Configuration.* Preliminary report.

A group divisible design GDD$(n,m;k,\lambda_1,\lambda_2)$ is a collection of k element subsets of a set of $v = nm$ points called blocks. These points are partitioned into m groups of size n, and the blocks have the property that each pair of points from the same group appears in exactly λ_1 blocks and each pair from different groups is in exactly λ_2 blocks. A GDD$(n,2,k;\lambda_1,\lambda_2)$ has (s,t) fixed block configuration if each block has exactly s points from one group and $k-s=t$ points from the other. We give a survey of past work of GDD's with fixed block configuration with block sizes 3,4 and 5 and some new results on block size 6. (Received September 20, 2010)

1067-05-1373 **Kim A.S. Factor** and **Sarah K. Merz*** (smerz@pacific.edu), Department of Mathematics, The University of the Pacific, Stockton, CA 95211, and **Yoshio Sano**. *The (l, m)-step competition number of a graph.*

Roberts introduced the competition number, $k(G)$ of a graph G: the smallest k so that G, together with k isolated vertices, is the competition graph of some acyclic digraph. The notion of the $(1, 2)$-step competition graph, more generally the (l, m)-step competition graph, of a digraph was introduced by Factor and Merz. The $(1, 2)$-step competition graph of digraph D, denoted $C_{(1,2)}(D)$ is a graph with vertex set $V(D)$ so that for $x \neq y$, $\{x.y\} \in E(C_{(1,2)}(D))$ if and only if for some vertex $z \in V(D)$, $dist_{D-y}(x, z) \leq 2$ and $dist(y, z) = 1$ or $dist_{D-x}(y, z) \leq 2$ and $dist(x, z) = 1$. We introduce the (l, m)-step competition number of a graph and give bounds or the exact values for some graphs. (Received September 20, 2010)

1067-05-1408 **Ae Ja Yee**, 327 McAllister Bldg, University Park, PA 16802, and **Kagan Kursungoz*** (kursun@math.psu.edu), 001 McAllister Bldg, University Park, PA 16802. *A Generalization of Algorithm-Z with Application.* Preliminary report.

We will remind algorithm-Z, and show how it is used in proving q-binomial theorem bijectively. Then we will present a generalization with one more parameter, and show how this generalization proves q-Gauss summation formula bijectively. We will discuss current related projects and open problems as time allows. (Received September 20, 2010)

1067-05-1414 **Katie Rose Banks*** (krbanks@fas.harvard.edu), 175 Cabot Mail Center, 60 Linnaean Street, Cambridge, MA 02138, and **Chang Mou Lim** (krbanks@fas.harvard.edu), Cambridge, 02138. *Efficient Domination of Tessellations and other Infinite Graphs with Extra Symmetry.* Preliminary report.

We prove the existence of efficient dominating sets for the infinite graphs obtained from the regular tesselations of the Euclidean plane We then consider the analogous problem for a wider class of tesselations, first Archimedean tilings of the plane, then tesselations of d-dimensional space for d>2. We also study other classes of in finite graphs that are highly symmetric and regular or "almost" regular, such as k-ary trees, the Sierpinski gasket graph, graphs obtained from hyperbolic tilings, graphs of nested polygons, and vertex-transitive planar graphs that are not tessellations, in terms of how efficient their dominating sets can be. We discuss the methods that unify our study of efficient domination on infinite graphs with additional structure that gives us a measure of how close to regular they are. These methods include the concept of the "growth rate of the boundary" of an infinite graph constructed iteratively, and the independence of domination fraction from which set of finite graphs is used to construct the infinite graph. (Received September 20, 2010)

1067-05-1429 **André Kündgen*** (akundgen@csusm.edu), Department of Mathematics, California State University San Marcos, San Marcos, CA 92096-0001, and **R. Bruce Richter** (brichter@math.uwaterloo.ca), Department of Combinatorics & Optimization, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada. *2-factors with long cycles in cubic graphs.*

Every 2-connected cubic graph G has a 2-factor, and much effort has gone into studying conditions that guarantee G to be Hamiltonian. We show that if G is not Hamiltonian, then G is either the Petersen graph or contains a 2-factor with a cycle of length at least 7. We also give infinite families of 2-connected and 3-connected cubic graphs in which every 2-factor consists of cycles of length at most, respectively, 10 and 16. (Received September 21, 2010)

1067-05-1432 **Dillon Mayhew*** (dillon.mayhew@msor.vuw.ac.nz), **Carolyn Chun**, **Geoff Whittle** and **Stefan van Zwam**. *Fragile matroids.* Preliminary report.

Let M and N be matroids. We say that M is N-fragile if, for every element e in M, either $M\backslash e$ or M/e does not have an N-minor.

The notion of fragility is not a new one. It appears, more or less explicitly, in work by Truemper, by Oxley, and by Kingan and Lemos. It also plays an important (but implicit) role in the excluded-minor characterization of GF(4)-representable matroids, due to Geelen, Gerards, and Kapoor. It is this application to excluded-minor characterizations that motivates us to study the structure of fragile matroids.

This talk will provide an overview of fragility and its applications, and a survey of recent progress. (Received September 21, 2010)

1067-05-1447 **Abbas Mahdi Alhakim*** (aa145@aub.edu.lb), Bliss Street, P.O.Box 11-0236, Beirut, Lebanon, and **Mufutau B Akinwande** (akinwamb@clarkson.edu). *A recursive Construction of Non-binary de Bruijn Sequences.*

We present a method to find new non-binary de Bruijn sequences of arbitrary order based on ones of lesser order. This is done recursively by mapping an existing de Bruijn sequence–regarded as a cycle in a de Bruijn digraph–to several vertex disjoint cycles in a higher order de Bruiin digraph. A new de Bruijn sequence is then obtained by connecting these cycles in any one of many different ways. This construction generalizes a well known binary construction due to Lempel. (Received September 21, 2010)

1067-05-1463 **Joe Buhler** and **Steve Butler*** (butler@math.ucla.edu), Dept of Mathematics, UCLA, Los Angeles, CA 90095-1555, and **Ron Graham** and **Eric Tressler**. *Hypercube orientations with only two in-degrees.*

We show that it is possible to orient the edges of the n-cube so that only the in-degrees a and b occur if and only if there are non-negative integers s and t so that $s+t=2^n$ and $as+bt=n2^{n-1}$. This is connected to a question arising from constructing strategies for a type of hat game. (Received September 21, 2010)

1067-05-1495 **Futaba Fujie-Okamoto*** (okamoto.futa@uwlax.edu), 1725 State St., La Crosse, WI 54601. *Modular Edge-Graceful Graphs.*

In an edge-graceful labeling of a graph G of order n and size m, distinct edges of G are assigned distinct labels from the set $\{1, 2, \ldots, m\}$ so that for every two distinct vertices of G the sums of the labels of their incident edges are distinct in $\mathbb{Z}_n$. A graph that admits an edge-graceful labeling is called an edge-graceful graph. When $m > n$, this edge labeling is not actually a bijective labeling. This suggests removing altogether the requirement that edge labelings be bijective. We study such modular edge-graceful labelings and resulting modular edge-graceful graphs, primarily focusing on which graphs are modular edge-graceful. (Received September 21, 2010)

1067-05-1499 **Wei-Tian Li*** (li37@mailbox.sc.edu), Department of Mathematics, University of South Carolina, 1523 Greene Street, Columbia, SC 29208. *Poset-Free Families in Boolean Lattices.*

The poset-free family problem original stems from the well-know Sperner's Theorem. The theorem states what is the maximum size of a chain-free family, that is a family of subsets such that no one is included in another, in the Boolean lattice.

Lubell, Yamamoto, Meschalkin individually used a similar idea of counting full chains that intersect the family to prove the Sperner's Theorem, which is now called LYM inequality.

In the talk, we will see how to modify this idea and use it to find the maximum size of the poset-free families for some special posets.

This is a joint work with Jerrold R. Griggs and Linyuan Lu. (Received September 21, 2010)

1067-05-1503 **J Kyle Pula*** (jpula@math.du.edu) and **Ian Wanless**. *Weak Transversals of Latin Squares.*

A latin square of order n is an $n \times n$ array with entries from an n-set of symbols such that no row or column contains a repeated symbol. Structures of this type occur in many forms throughout both pure and applied mathematics as, for example, Cayley tables of finite groups, subsets of lines in affine planes, and efficient statistical designs. A weak transversal of a latin square is a collection n cells that meets each row and column once and no symbol more than twice. We discuss a conjecture that every latin square can be partitioned into weak transversals and present some initial results in this direction. (Received September 21, 2010)

1067-05-1526 **Brooks E Smith*** (bsmith26@nd.edu), 1153 South Highland Avenue, Oak Park, IL 60304, and **Chang Mou Lim** (changmou.lim@yale.edu) and **Antonio Blanca** (ablanca3@gatech.edu). *Graphs with large second neighborhood.* Preliminary report.

In 1990 Paul Seymour conjectured that every directed graph contains a vertex with second neighborhood at least as large as its first neighborhood. We introduce the notion of "super-Seymour graphs" – graphs in which at least k vertices have second neighborhood at least the size of the first neighborhood plus some constant – and study their structure in hopes of characterizing Seymour graphs themselves, or shedding light on the structure of a counterexample. In addition, we demonstrate that the conjecture holds for graphs of diameter 2, planar graphs, and k-connected graphs with minimum outdegree k, and provide a proof that every vertex is Seymour in certain graphs. (Received September 21, 2010)

1067-05-1553 **Nathaniel Dean*** (nd17@txstate.edu), President, National Assoc. of Mathematicians, Department of Mathematics, 601 University Drive, San Marcos, TX 78666. *Screen Size.*

Graph drawing has numerous applications, and so there are numerous criteria for a nice or optimal drawing of a graph, such as few crossings, small area, symmetry, uniform edge lengths, angular resolution, and certain clustering properties. Often the graph must be drawn on a device such as a computer screen where the vertices are mapped to distinct points of an integer lattice. This very practical restriction suggests a graph invariant called the screen size of a graph G which is the smallest integer k such that some set of points in a $k \times k$ integer lattice realizes G, subject to a prescribed set of constraints. For two examples, we consider sphere-of-influence graphs which arise in pattern recognition and computer vision and crossing minimal, straight line drawings of graphs which arise in circuit layout applications. This talk presents bounds and open problems on the screen size for various graph families. (Received September 21, 2010)

1067-05-1555 **Likin C. Simon Romero*** (lsrsma@rit.edu), 85 Lomb Memorial Drive, Rochester, NY 14623-5603. *Hyperspace Graph of Connected Subgraphs.*

Given a connected graph G with N edges and a positive integer $n < N + 1$, we define the nth-size level graph $\mathcal{Q}n(G)$ such that every vertex of $\mathcal{Q}_n(G)$ represents a connected subgraph of G with n edges. Similarly, the Hyperspace Graph of Connected Subgraphs $\mathcal{C}(G)$ is the graph such that every vertex represents a connected subgraph of G with a special adjacency relation.

This concept was created by the author as an analogous version to the hyperspace of sets in topology. This work opens a new ground for research. In this talk we will give a detailed explanation of the two definitions and present some results concerning such graphs. (Received September 21, 2010)

1067-05-1583 **Stan Dziobiak*** (standzio@math.lsu.edu), Louisiana State University, Department of Mathematics, Baton Rouge, LA 70803, and **Guoli Ding** (ding@math.lsu.edu), Louisiana State University, Department of Mathematics, Baton Rouge, LA 70803. *3-connected graphs of path-width at most three.*

It is known that the list of excluded minors for the minor-closed class of graphs of path-width $\leqslant 3$ numbers in the millions. However, if we restrict our class to 3-connected graphs of path-width $\leqslant 3$, then we can characterize it by five excluded minors. (Received September 21, 2010)

1067-05-1593 **Guoli Ding**, LSU, and **Cheng Liu***, School of Mathematical Science and Computing, Central South University, Changsha, China. *Excluding a small minor.*

There are sixteen 3-connected graphs on eleven or less edges. For each of these graphs H we discuss the structure of graphs that do not contain a minor isomorphic to H. (Received September 21, 2010)

1067-05-1597 **Ellen Panofsky*** (erp39@cabrini.edu), 610 King of Prussia Rd, Radnor, PA 19087, and **Garth Isaak**. *L(2,1) Labeling of Graphs of Bounded Bandwidth and Permutation Graphs.* Preliminary report.

An L(2,1) labeling of a graph has labels of adjacent vertices differing by at least two and different labels for vertices at distance two. The minimum span of such a labeling is called the L(2,1) number and is denoted $\lambda_{2,1}(G)$ for any graph G. Griggs and Yeh conjectured that for every graph G, $\lambda_{2,1}(G) \leq \Delta^2$. Calamoneri et al. showed that $4\Delta + 1$ for permutation graphs and asked about a similar bound for AT-free graphs. We extend their result to graphs of bounded bandwidth and in particular, show $\lambda_{2,1}(G) \leq 6\Delta + 3$ for AT-free graphs. We also improve the permutation graphs bound when $\Delta = 3, 4$ in order to show the Griggs-Yeh bound for all Δ. (Received September 21, 2010)

1067-05-1614 **Valerio De Angelis*** (vdeangel@xula.edu), Mathematics Department, Xavier University of Louisiana, 1, Drexel Drive, New Orleans, LA 70125, and **Victor H Moll** and **Tewodros Amdeberhan**. *The 2-adic valuation of the complementary Bell numbers.*

The n-th Bell number $B(n)$ is the number of partitions of a set with n elements. The n-th complementary Bell number $B1(n)$ is the difference between the number of such partitions with an even number of sets, and those with an odd number of sets. While the 2-adic valuation (or largest power of 2 factor) of $B(n)$ is easily calculated, the 2-adic valuation of $B1(n)$ is harder to find. In this talk we present explicit values of the 2-adic valuation of $B1(n)$ when $n \not\equiv 14 \pmod{24}$, and show how the 2-adic valuation of $B1(24n + 14)$ is related to the binary expansion of n. As a consequence, we find that $B1(n)$ is zero for at most one number $n > 2$. (Received September 21, 2010)

1067-05-1632 **Andrew B Ray*** (ray.andrew@gmail.com), 2532 T St. Apt. 5, Lincoln, NE 68503.
Reconstruction of graphs from metric balls of their vertices.

Given a graph G, the metric ball of radius r about a vertex v is $B_r(v) = \{w \in V(G) : d(v,w) \leq r\}$. We prove a conjecture of Levenshtein, that if G has girth at least $2r+3$ and no terminal vertices then we can reconstruct G from the function B_r. This is best possible since a cycle on $2r+2$ vertices cannot be reconstructed in this way. The previous best known result was for graphs with girth at least $2r+2\lceil(r-1)/4\rceil+1$ and no terminal vertices. (Received September 21, 2010)

1067-05-1633 **Matthew Price Yancey*** (yancey1@illinois.edu), 1409 W. Green Street, Urbana, IL 61801-2975. *On extremal graphs with a given number of perfect matchings.*

We consider the problem of maximizing the number of edges in a graph G on n vertices under the restriction that the number of perfect matchings in G is a given constant p. Dudek and Schmitt showed that this number approaches $\frac{n^2}{4}+c_p$ as n grows, where c_p is a constant depending only on p. This work extends the understanding of the sequence c_p, including some constructive lower bounds and a conjecture on its exact value. Moreover, we present some structural results on graphs which achieve the extremal number of edges.

This is part 1 of this talk. (Received September 21, 2010)

1067-05-1651 **Sibel Ozkan** (sozkan@mtu.edu) and **Erik E Westlund*** (erik.westlund@uwc.edu). *Hall m-completable graphs.* Preliminary report.

A partial proper m-coloring of a graph G is a proper coloring $\varphi : V_0 \to \{1,\ldots,m\}$, for some $V_0 \subseteq V(G)$. Define the list-assignment $L = L_\varphi$ by $L(v) = \{\varphi(v)\}$ if $v \in V_0$, and $L(v) = \{1,\ldots,m\} \setminus \{\varphi(N_G(v) \cap V_0)\}$ if $v \in V \setminus V_0$, where $N_G(v)$ denotes the neighborhood of v. φ has a completion to a proper m-coloring of G if and only if G has a proper L_φ-coloring. We say (G,L) satisfies Hall's condition if, for all subgraphs H of G, $|V(H)| \leq \sum_{\sigma\in\mathcal{C}} \alpha(H(\sigma,L))$, where $\alpha(H(\sigma,L))$ is the independence number of the subgraph of H induced on the vertices having σ in their lists. Hall's condition is necessary for G to have a proper L-coloring. G is said to be Hall m-completable, for some $m \geq \chi(G)$, if ever partial proper m-coloring φ, such that (G,L_φ) satisfies Hall's condition, has a completion. In this talk, we discuss new results in classifying Hall m-completable graphs for certain values of m. (Received September 21, 2010)

1067-05-1652 **Taylor M Short*** (shorttm@vcu.edu), 4156 Grace E. Harris Hall, 1015 Floyd Avenue, Richmond, VA 23220. *Vertices Belonging to All Maximum Independent Sets.* Preliminary report.

For a graph G, let $\xi(G)$ be the number of vertices belonging to all maximum independent sets. Boros, Golumbic and Levit showed that in connected graphs where the independence number $\alpha(G)$ is greater than the matching number $\mu(G)$, $\xi(G) \geq 1+\alpha(G)-\mu(G)$. We will show there is a distinguished subgraph X such that, under weaker assumptions, $\xi(G) \geq 1+\alpha(X)-\mu(X)$. Furthermore $1+\alpha(X)-\mu(X) \geq 1+\alpha(G)-\mu(G)$ and the difference between these bounds can be arbitrarily large. (Received September 21, 2010)

1067-05-1667 **Tianhui Cai*** (tcai@fas.harvard.edu), 174 Cabot Mail Center, 60 Linnaean Street, Cambridge, MA 02138. *Coin set extensions in the greedy change-making problem.*

Given a finite sequence $A = (1, a_1, \ldots, a_k)$ of positive integer coin denominations, we can make change for a positive integer amount x using the greedy algorithm, that is, by iteratively choosing the largest coin value $a_{i_1} \leq x$, then the largest coin $a_{i_2} \leq x - a_{i_1}$, and so on. Call a coin set *orderly* if, for every positive integer x, the greedy algorithm makes change for x with the fewest possible number of coins. Call a coin set B an *extension* of a coin set A if $B \supset A$ and all coins in $B-A$ are larger than the largest coin in A. Call a coin set an *obstruction* if it cannot be extended to an orderly coin set. We present a new characterization of orderly coin sets, and use this characterization to find simple conditions for when a one-coin extension is orderly. We also present a series of sufficient conditions to determine if a coin set is an obstruction, and we fully characterize all obstructions of length four. (Received September 21, 2010)

1067-05-1682 **Igor Rivin*** (rivin@ias.edu), Institute for Advanced Study, School of Mathematics, Einstein Drive, Princeton, NJ 08540. *Asymptotic phenomena in geometric group theory.*

I will describe some recent result on generic phenomena in geometric group theory. (Received September 21, 2010)

1067-05-1695 **E. Rodney Canfield***, Department of Computer Science, University of Georgia, Athens, GA 30602. *The Asymptotic Hadamard Conjecture.* Preliminary report.

The Hadamard Conjecture states that for every integer n which is divisible by 4 there is an $n \times n$ matrix over $\{\pm 1\}$ whose rows are pairwise orthogonal. The first value of n in question is 668. Let $H_{n,t}$ equal the number of $n \times t$ matrices over $\{\pm 1\}$ whose rows are pairwise orthogonal. The Asymptotic Hadamard Conjecture states that for $t > n^{1+\epsilon}$

$$H_{n,4t} \sim \frac{2^{4nt+(n-1)^2}}{(8\pi t)^{d/2}}, \ d = \binom{n}{2}.$$

Warwick de Launey and David Levin have proven the conjecture for $t > n^{12+\epsilon}$ (2010). We review their work, and report on our efforts to improve upon it. (Received September 21, 2010)

1067-05-1713 **Beth A Novick*** (nbeth@clemson.edu), Beth Novick, Department of Mathematical Sciences, O-110 Martin Hall, Box 340975, Clemson, SC 29634-0975, and **Henry Martyn Mulder**. *An intuitively appealing axiomatization of the median procedure on median graphs.*

A profile of length k on a finite connected graph G is a k-tuple $x_1, ..., x_k$ of vertices of G, with repetition allowed. A median m of a profile is a vertex for which the sum of geodesic distances from m to all vertices in the profile is minimum. The median procedure finds the set of all medians of a profile. Medians are important in location theory and in the consensus theory of voting. A median graph is a graph for which every profile of length 3 has a unique median. Median graphs have been well studied and arise in many arenas, including ternary algebra, ordered sets and discrete distributed lattices.

We establish a succinct axiomatic characterization of the median procedure on median graphs. This is a simplification of the of the characterization given by McMorris, Mulder and Roberts in 1998: we show that the median proceedure can be characterized on the class of all median graphs with only three simple and intuitively appealing axioms. (Received September 21, 2010)

1067-05-1723 **Heather M. Shappell***, 121 West Savory Street, Pottsville, PA 17901, and **Katherine Grzesik** and **Mike Donders**. *Planarized Pascal's triangle mod a general prime p graphs and their Properties.*

We have generalized results of Teguia and Godbole on planarized Pascal's triangle fractal graphs mod 2 to the case of graphs similarly constructed with Pascal's triangle mod a general prime p. This talk will focus on proper colorings of these graphs, as well as pebbling number, domination number, and path-oriented properties, including Hamiltonicity, pancyclicity, diameter and radius. (Received September 21, 2010)

1067-05-1733 **Palle E. T. Jorgensen** and **Erin P. J. Pearse*** (ep@ou.edu), Dept of Mathematics, 810 Physical Sciences Center, Norman, OK 73019-0315. *Resistance analysis of infinite networks.*

I will discuss effective resistance as a tool for the analysis of infinite networks (connected weighted graphs). I will also describe how effective resistance can be used in conjunction with a discrete version of the Gauss-Green formula to study the Hilbert space $\mathcal{H}_\mathcal{E}$ of functions of finite energy on a network, and how this leads to a boundary representation for the harmonic functions of finite energy.

The boundary here is not part of the original network; it must be constructed in a manner analogous to Martin boundary (in the theory of Markov processes). However, instead of extending the space directly (via metric completion) as in the case of Martin boundary, the *resistance boundary* is obtained by first embedding the network into the space of finite-energy functions $\mathcal{H}_\mathcal{E}$, and then extending this function space. This essentially corresponds to the construction of a suitable class of distributions, defined with respect to a certain space of "test functions" of finite energy. As a result, the boundary of the original network can be studied in terms of certain linear functionals on $\mathcal{H}_\mathcal{E}$. (Received September 21, 2010)

1067-05-1738 **Zachary Kudlak*** (zachary.kudlak@msmc.edu), Mount Saint Mary College, 333 Powell Avenue, Newburgh, NY 12550, and **Luboš Thoma**. *On a (p,q)-edge coloring of K_n.*

For integers $p \leq n$ and $q \leq \binom{p}{2}$ an edge coloring of K_n is said to be a (p,q)-edge coloring if for every induced subgraph on p vertices there are at least q colors used on its edges. Let $f(n,p,q)$ be the minimum number of colors needed in such an edge coloring. We will show that if $p \geq 6$ and $q = 2\lceil \log_2 p \rceil - 4 + \left\lceil \frac{4p}{2^{\lceil \log_2 p \rceil}} \right\rceil$, then $f(n,p,q) \leq e^{O(\sqrt{\log n})}$. In particular the case for $p = 7$ yields $f(n,7,6) \leq e^{O(\sqrt{\log n})}$. (Received September 21, 2010)

1067-05-1745 **Sarah H Holliday***, SPSU Math Department, 1100 S Marietta Pkwy, Marietta, GA 30060. *Sequences of matchings.* Preliminary report.

A matching in a graph is a set of edges that do not share endpoints. By counting the number of matchings in certain families of graphs, we can generate familiar sequences. (Received September 21, 2010)

1067-05-1750 **L. Marie Chism*** (lmchism3@hotmail.com). *On Independence Polynomials and Independence Equivalence in Graphs.*

Informally, a graph is a collection of vertices, some pairs of which are joined by edges. An independent set in a graph is a collection of vertices no two of which are joined by an edge. If G is a graph and $k > 0$ is an integer, then I denote by "$f_k(G)$" the number of k-vertex independent sets in G. The independence polynomial of G is $f_G(x) = \sum f_k(G)x^k$, where $f_G(x)$ is the generating function for the numbers $\{f_k(G)\}$. Most of the previous results are inequalities and asymptotic estimates, but exact formulas have been found for only a few classes of graphs such as paths, cycles, and $2 \times n$ lattices. I have studied the independence polynomial for some classes of graphs and found exact formulas in several cases. Among my results are closed formulas for $2 \times n$ lattices, Möbius ladders, and combs. For each of these classes of graphs, I generate a combinatorial identity. I have also considered "matching polynomials," that is, independence polynomials of line graphs, and derived a closed expression for the matching polynomials of some generalized combs. I last have investigated "independence equivalence," the phenomenon of non-isomorphic graphs having identical polynomials finding several infinite classes of such pairs of graphs. (Received September 21, 2010)

1067-05-1751 **Palmer C Mebane***, 2821 W Brigstock Rd, Midlothian, VA 23113. *Exhaustive Random Permutations.* Preliminary report.

Consider a game in which n people randomly shuffle their wallets. Anyone who gets their own wallet leaves, and the remaining people shuffle again, continuing until everyone leaves. The random variable X_n is defined as the amount of time it takes for the game to end with n people. Using a recurrence relation we will derive some basic results about the moments of X_n. We will then show some investigations toward finding the limiting distribution of this random variable as $n \to \infty$. (Received September 21, 2010)

1067-05-1762 **Douglas J. Klein*** (kleind@tamug.edu), D. J. Klein, MARS, TAMUG, Galveston, TX 77553. *Chemical Sub-Structural Cluster Expansions.*

Molecular structure-property correlation has a long history, and still remains of chemical interest. For an analysis in terms of sub-structures, typically graphs arise with colored vertices and decorated edges. Initially restriction may be to simple graphs, representing singly bonded hydrocarbons, though common mathematical subgraph counting polynomials need extension, particularly for expansions arising in statistical mechanics and many-body quantum mechanics. Focus here is on general sub-structural cluster expansions for a connected graph G belonging to a "universe" U of (molecular) graphs. A real-valued graph invariant is expanded as a linear combination of variables each corresponding to an isomorphism class of subgraphs satisfying "C-subgraph" conditions, which in addition to being a subgraph H of G also include possibilities of H being spanning or connected, and perhaps induced, isometric, or convex (just for the components if disconnected). The general C-subgraphs lead to a complete expansion, for which Möbius inversion is conceivable. In applications the expansions are truncated to subgraphs H of smaller "size", whence questions arise, say as to rapidity of convergence. (Received September 21, 2010)

1067-05-1773 **Joshua E Ducey*** (jducey21@ufl.edu), 358 Little Hall, Department of Mathematics, University of Florida, Gainesville, FL 32611. *Integer invariants of skew lines in PG(3,q).*

Consider the incidence matrix A with rows and columns indexed by the lines in PG(3,q), where two lines are defined to be adjacent when they are skew. In this talk the Smith Normal Form of A is computed, in the case when the field is of prime order. As for the prime-power case, a conjectured formula for the invariant factors of A is given. I will also discuss some related problems and what work has been done in this general area. Joint work with Peter Sin. (Received September 21, 2010)

1067-05-1800 **Nafiseh Jahanbakht*** (nafiseh.jahanbakht@uleth.ca). *A new class of hyper-energetic graphs.* Preliminary report.

Suppose $\lambda_1, \lambda_2, \cdots, \lambda_n$ are the eigenvalues of the adjacency matrix of a graph G. The *energy* of the graph G, denoted by $\mathcal{E}(G)$, is $\mathcal{E}(G) = \sum_{i=1}^{n} |\lambda_i|$. A graph with n vertices is called hyperenergetic if its energy is grater than $2n-2$. Several classes of graphs have been proved to be hyperenergetic. We found a new class of graphs which are hyperenergetic. (Received September 21, 2010)

1067-05-1821 **Maria Axenovich*** (axenovic@iastate.edu), 412 Carver Hall, Ames, IA 50010, and **Joan Hutchinson** and **Michelle Lastrina**. *On pre-coloring extension to list-colorings.*

The famous theorem of Thomassen states that no matter how the lists of 5 colors are assigned to the vertices of a planar graph, there is always a way to choose a color for each vertex from its list such that the resulting coloring is proper (so that adjacent vertices receive distinct colors). Earlier, Erdős, Rubin, and Taylor, and,

independently, Borodin proved that any graph (with few exceptions) could be properly colored from any list assignment if the list size of each vertex is equal to its degree. Here, we shall show how to strengthen these results when some distant vertices are precolored. (Received September 21, 2010)

1067-05-1851 **Adam Hesterberg*** (ahesterb@princeton.edu), 4342 Frist Center, Princeton, NJ 08544.
Iterated Iteratedly Piecewise Continuous Function Order Pattern Probability Distributions.
Given a function f from $[0,1]$ to itself and a point $x \in [0,1]$, we consider the order of the iterates x, $f(x)$, ..., $f^{n-1}(x)$, an element of S_n. For suitable functions f, the choice of a random point in $[0,1]$ induces a probability distribution on S_n. We characterize probability distributions that arise thusly when f and its iterates are restricted to be piecewise continuous. (Received September 22, 2010)

1067-05-1853 **Joshua Hanes***, Department of Sciences and Mathematics, 1100 College St., MUW-100, Columbus, MS 39701, and **Tristan Denley**, 601 College St., Clarksville, TN 37044.
Distance Labelings of Trees. Preliminary report.
Let V be a non-empty set, $\phi : V \to Z^+$ be an injective function, and $D \subseteq Z^+$. The **distance graph** $G(\phi, D)$ is the graph with vertex set V and edge set defined by$(u,v) \in E(G) \iff |\phi(u) - \phi(v)| \in D$ for $u, v \in V$.

In [2] Ferrera, Kohayakawa and Rödl introduced this construction, and investigated a variety of parameters connected with representing graphs in this way. In particular they considered $D(G) = \min_{G(\phi,D)\cong G} |D|$. Whilst $D(G)$ is always at most $|E(G)|$ they showed that there are graphs on n vertices for which $D(G) \geq \binom{n}{2} - n^{3/2}(\log n)^{1/2+o(1)}$.

We shall consider a variety of properties of this parameter. In particular we shall show that given $\Delta \geq 2$ and $n \geq 3$ for any tree on $n \geq 3$ vertices with maximum degree Δ, $D(T) \leq \log_{\frac{\Delta}{\Delta-1}} n + 1$. Indeed we shall also show the existence of trees on n vertices with max degree Δ for which $D(T) \geq \frac{\log n}{\log(\log_{\Delta-1}(n^2)+1)}$. (Received September 22, 2010)

1067-05-1905 **Michael E Young*** (myoung@iastate.edu) and **Giuseppe Mazzuoccolo** (giuseppe.mazzuoccolo@unimore.it). *Graphs of arbitrary excessive class.*
A 1-factor of a graph is a collection of independent edges, which together are incident on all the vertices of the graph. An *excessive factorization* is a minimum cover of the edge-set of a graph by a set of 1-factors. If such a cover exists, we denote the cardinality by $\chi'_e(G)$. The excessive class of an r-regular graph G is defined as $exc(G) = \chi'_e(G) - r$. We show that there exists a family of r-regular graphs of arbitrarily large excessive index for each integer r greater than 3. Furthermore, we answer a question by Bonisoli and Cariolaro showing that all the positive integers can be attained as excessive classes of regular graphs. (Received September 22, 2010)

1067-05-1944 **Jianning Su*** (jsu007@latech.edu), Program of Mathematics and Statistics, P. O. Box 10438, Louisiana Tech University, Ruston, LA 71272, **Jinko Kanno** (jkanno@latech.edu), Program of Mathematics and Statistics, P. O. Box 10438, Louisiana Tech University, Ruston, LA 71272, and **Ko Yamamoto**. *Generating Planar Quintangulations.* Preliminary report.
A *quintangulation* is a 2-connected simple plane graph with each face bounded by a closed walk of length five. We define the standard form of the quintangulation and show that every quintangulation can be transformed into the standard form by two kinds of diagonal transformations. As a corollary, we prove that any two quintangulations with the same number of vertices can be transformed into each other. (Received September 22, 2010)

1067-05-2004 **Arthur Busch*** (art.busch@udayton.edu), **Michael Ferrara**, **Michael Jacobson** and **Stephen Hartke**. *Ramsey-type Numbers for Degree Sequences.*
A (finite) sequence of non-negative integers is graphic if it is the degree sequence of some simple graph G. Given graphs G_1 and G_2, we define the *potential-Ramsey number*, $r_{pot}(G_1, G_2)$, as the smallest integer n such that for every n-term graphic sequence π, there is some graph G with degree sequence π with $G_1 \subseteq G$ or with $G_2 \subseteq \overline{G}$. Bounded above by the well-studied classical Ramsey number, we consider situations where equality holds, and give exact values for $r_{pot}(K_n, K_t), r_{pot}(C_n, K_t), r_{pot}(P_n, K_t)$. (Received September 22, 2010)

1067-05-2007 **Ralucca M Gera*** (rgera@nps.edu), 1 University Way, Monterey, CA 93943, and **Andrew Chen**, **Daniela Ferrero** and **Eunjeong Yi**. *Functigraphs: A Generalization of Permutation Graphs.*
Let G_1 and G_2 be disjoint copies of a graph G, and let $f : V(G_1) \to V(G_2)$ be a function. Then a *functigraph* $C(G, f) = (V, E)$ has the vertex set $V = V(G_1) \cup V(G_2)$ and the edge set $E = E(G_1) \cup E(G_2) \cup \{uv \mid u \in V(G_1), v \in V(G_2), v = f(u)\}$. A functigraph is a generalization of a *permutation graph* (also known as a

generalized prism) in the sense of Chartrand and Harary. We present general results on functigraphs, with emphasis on colorings and planarity. (Received September 22, 2010)

1067-05-2029 **Michael William Schroeder*** (schroede@math.wisc.edu), 480 Lincoln Dr., Madison, WI 53706. *ϕ-Symmetric Hamilton Cycle Decompositions of Graphs.* Preliminary report.

Let G be a graph on n vertices. Let ϕ be a non-trivial vertex automorphism of G. A ϕ-symmetric Hamilton cycle decomposition of G is a Hamilton cycle decomposition of G for which each Hamilton cycle is fixed (as an edge set) by ϕ. We will discuss recent results involving complete multi-partite graphs and automorphisms of degree larger than 2. (Received September 22, 2010)

1067-05-2049 **Lauren R. McGough*** (unreal@mit.edu). *Maximal minimal k-rankings of caterpillar trees and cycles.*

Given a graph G, a map $f\colon V(G) \to \{1,\dots,k\}$ is a k-ranking of G if $f(u) = f(v)$ implies that on every $u - v$ path, there exists a vertex w such that $f(w) > f(u)$. A k-ranking is called minimal if we cannot decrease the label of any vertex and still have a k-ranking. The arank of G is the maximum k for which there exists a minimal k-ranking of G. We compute the arank of some caterpillar trees as well as some cycles. (Received September 22, 2010)

1067-05-2058 **Sarah Spence Adams** (Sarah.Adams@olin.edu), Olin Hall, Needham, MA 02492, **Paul Booth*** (Paul.Booth@students.olin.edu), Olin Hall, Needham, MA 02492, **Harold Jaffe** (Harold.Jaffe@students.olin.edu), Olin Hall, Needham, MA 02492, **Denise Sakai Troxell** (troxell@babson.edu), Babson Hall, Babson Park, MA 02457, and **Steven Luke Zinnen** (steven.zinnen@students.olin.edu), Olin Hall, Needham, MA 02492. *On the λ-numbers of subclasses of generalized Petersen graphs.*

An L(2,1)-labeling of a graph G is an assignment f of nonnegative integers to the vertices of G such that if vertices x and y are adjacent, $|f(x) - f(y)| \geq 2$, and if x and y are at distance two, $|f(x) - f(y)| \geq 1$. These labelings have been used to model the channel assignment problem when sufficiently different frequencies must be assigned to transmitters operating in close proximity. The λ-number of G is the smallest number k for which G has an L(2,1)-labeling using labels in the set $\{0, 1, ..., k\}$. We determine the λ-numbers of certain generalized Petersen graphs (GPGs). A GPG of order n consists of two disjoint copies of the same cycle C_n together with a perfect matching between the two vertex sets. We designed an algorithm that reduced the computation time required to determine the λ-numbers of GPGs for previously intractable cases. More specifically, we provide exact λ-numbers of all GPGs of orders 9, 10, 11, and 12, bringing down to 6 the known upper bound of 7 for all but one graph. We also provide the λ-numbers of several infinite subclasses of GPGs that have useful representations on Möbius strips. (Received September 22, 2010)

1067-05-2068 **Michael Ferrara**, **Michael Jacobson**, **Kevin Milans**, **Craig Tennenhouse** and **Paul S Wenger*** (paul.wenger@ucdenver.edu), UCD Department of Mathematics, Campus Box 170, P.O. Box 173364, Denver, CO 80217. *Saturation Numbers for Families of Subdivisions.*

A graph G is *$\mathcal{F}$-saturated* for a family of graphs $\mathcal{F}$ if G contains no member of $\mathcal{F}$ as a subgraph, but $G + uv$ contains some member of $\mathcal{F}$ for every uv in $\overline{G}$. The minimum number of edges in an $\mathcal{F}$-saturated graph of order n is denoted $\mathrm{sat}(n, \mathcal{F})$. A *subdivision* of a graph H, is a graph G obtained from H by replacing the edges of H with internally disjoint paths of arbitrary length. We let $\mathcal{S}(H)$ denote the family of subdivisions of H, including H itself.

In this talk, we consider $\mathrm{sat}(n, \mathcal{S}(H))$ when H is a cycle or complete graph. We determine $\mathrm{sat}(n, \mathcal{S}(C_t))$ asymptotically and provide upper bounds on $\mathrm{sat}(n, \mathcal{S}(K_t))$. We also show that $\mathrm{sat}(n, \mathcal{S}(K_5)) = \lceil \frac{3n+4}{2} \rceil$, providing an interesting contrast to a 1935 result of Wagner, who showed that edge-maximal graphs without a K_5-minor have at least $\frac{11n}{6}$ edges. (Received September 22, 2010)

1067-05-2082 **Camillia Smith Barnes*** (cbarnes@sbc.edu), Sweet Briar College, Dept of Mathematical Sciences, 134 Chapel Road, Sweet Briar, VA 24595. *Shuffles of permutations.*

A shuffle of two words is an interlacing of the letters in the words such that these letters retain their original order when restricted to the given words. For example, 142356 and 415263 are shuffles of the words 123 and 456. In this talk, I will discuss enumeration of the distinct shuffles of permutations and address recent progress on questions such as: how can we put a partial ordering on the symmetric group such that the number of distinct shuffles with the identity permutation is monotone increasing? (Received September 22, 2010)

1067-05-2103 **Sarah Spence Adams** (Sarah.Adams@olin.edu), Olin Hall, Needham, MA 02492, **Zachary Brass** (Zachary.Brass@students.olin.edu), Olin Hall, Needham, MA 02492, **Connor Stokes*** (Connor.Stokes@students.olin.edu), Olin Hall, Needham, MA 02492, **Denise Sakai Troxell** (troxell@babson.edu), Babson Hall, Babson Park, MA 02457, and **Steven Luke Zinnen** (steven.zinnen@students.olin.edu), Olin Hall, Needham, MA 02492. *Dynamic Monopolies and k-Conversion Sets in Graph Products and Triangular Grids: Modeling the Spread of Fault in Distributed Network Systems.*

In a graph theoretical model of faults in distributed computing and communication networks, each element in the network is represented by a vertex of a graph where edges connect pairs of communicating elements, and each colored vertex corresponds to a faulty element at discrete time periods. We will focus on two processes that have been used to model the spread of fault to a certain vertex by checking for faults within its neighbors. These processes have also been used to model the spread of disease and opinion through social networks. In a majority (resp., k-conversion) process, a vertex becomes permanently colored in a certain time period if the majority (resp., at least k) of its neighbors were in the colored state in the previous time period. A dynamic monopoly (resp., k-conversion set) is a set of vertices which, if initially colored, will result in all vertices eventually being colored in a majority (resp., k-conversion) process. We answer several open problems by presenting bounds and some exact values for the minimum number of vertices in dynamic monopolies and/or k-conversion sets for several types of graphs, including Cartesian and tensor products, as well as planar, cylindrical and toroidal triangular grid graphs. (Received September 22, 2010)

1067-05-2134 **Seth A. Meyer*** (smeyer@math.wisc.edu), 480 Lincoln Dr., Madison, WI 53706. *Zero Forcing Sets and Bipartite Circulants.* Preliminary report.

Consider a graph whose vertices are each colored either black or white. We will study the following phenomenon: we allow a black vertex v to change a white neighbor w to black whenever all the neighbors of v other than w are black. Any set of black vertices is called a zero forcing set as long as when the graph is entirely white except for these vertices, repeated applications of the previous rule eventually make every vertex black. In this talk we will discuss both the minimum size of a zero forcing set for bipartite graphs and applications to problems concerning the minimum rank of matrices given by these graphs. (Received September 22, 2010)

1067-05-2151 **Gelasio Salazar*** (gsalazar@ifisica.uaslp.mx), Instituto de Fisica, UASLP, Av Manuel Nava 6. Zona Universitaria, 78290 San Luis Potosi, SLP, Mexico, and **Cesar Hernandez-Velez** and **Laurent Beaudou**. *Making graphs crossing-critical by multiplying their edges.*

We show that every sufficiently connected near-planar graph can be made crossing-critical by a suitable multiplication (that is, addition of parallel edges) of its edges. (Received September 22, 2010)

1067-05-2154 **Derksen Harm***, 530 Church Street, Ann Arbor, MI 49109-1043. *Complexity of the Graph Isomorphism Problem.* Preliminary report.

It is unknown whether the Graph Isomorphism Problem lies in the polynomial time complexity class. We will present an algorithm which can distinguish may classes of graphs in polynomial time, including the Cai-Fürer-Immerman examples. The CFI examples cannot be distinguished by the classical higher dimensional Weisfeiler-Lehman method. Our approach uses truncated Gröbner bases to construct certain approximate categories. (Received September 22, 2010)

1067-05-2155 **Darin Johnson*** (dbjohnson@desu.edu), Mathematical Sciences, Delaware State University, 1200 N DuPont HWY, Dover, DE 19901. *Distances in Kneser Graphs.*

In this talk we discuss the distance distribution of the Kneser Graph $K(n, k)$. We present exact but complicated formulas for the Expected Distance and Variance. We then give an simpler asymptotic formula for the Expected Distance. In addition, we prove central and local limit theorems for a related sequence, which allows us to prove much stronger results about the distance distribution for a special case. (Received September 22, 2010)

1067-05-2175 **Omid Ghayour Najafabad*** (texinfo@gmail.com), Department of Mathematics, Ahvaz, Khoozestan 61357. *Distribution Networks - A Generalization to Graphs: more application and less fuzzification.*

In this presentation we will show some interesting points in one of the generalizations of graphs and concept of edge in a graph and minimum spanning trees, including a generalization of matrix-tree theorem, based on the effects of replacing the initial points and final points of an edge by special fuzzy sets, called initial and final shares, c_i and c_o. The generalization noticed here is called, distribution network, which is, $N = (V, C)$, a pair of vertices set, V, and distribution companies or distribution channels set, C. For each $c \in C$ we have c_i, a function showing the share of each vertex in the input of the company, c; and similarly c_o which shows the share in the output. If applied to graphs (resp. directed-graphs) and $e = uv$, then c_i and c_o are characteristic function $\chi_{u,v}$ both (resp. functions χ_u and χ_v). By redefinition of graphs using these functions, we can make a backward compatibility and induce several concepts in distribution networks, e.g. minimal spanning subset of companies, and point to the concept found from the Matrix-Tree theorem for distribution networks. In this work we have shown several problems dealing with such ideas, including the algebraic extensibility. (Received September 22, 2010)

1067-05-2201 **Ryan C Bunge*** (rc_bunge@hotmail.com), Mathematics Department, Illinois State University, Normal, IL 61790-4520, and **Avapa Chantasartrassmee**, **Saad El-Zanati** and **Charles Vanden Eynden**. *On graph labelings and cyclic G-designs.*

A labeling (or valuation) of a graph G is an assignment of integers to the vertices of G subject to certain conditions. A hierarchy of graph labelings was introduced by Rosa in the late 1960s. Rosa showed that certain basic labelings of a graph G with n edges yielded cyclic G-decompositions of K_{2n+1} while other stricter labelings yielded cyclic G-decompositions of K_{2nx+1} for all natural numbers x. Until recently, labelings of the latter type were defined only for bipartite and almost-bipartite graphs. We introduce two new labelings for tripartite graphs and show that if a graph G with n edges admits either of these labelings, then there exists a cyclic G-decomposition of K_{2nx+1} for every positive integer x. We also report on classes of tripartite graphs that admit these labelings. (Received September 22, 2010)

1067-05-2213 **Wannasiri Wannasit*** (nasit049@yahoo.com), Department of Mathematics, Chiang Mai University, Chiang Mai, 502200, Thailand, and **Saad El-Zanati**. *On Rosa-Type Labelings of 3-regular Graphs.*

A labeling of a graph G is an assignment of integers to the vertices of G subject to certain conditions. Several labelings were introduced by Rosa in the late 1960's as means of obtaining cyclic graph decompositions. Rosa showed that certain basic labelings of a graph G with n edges yielded cyclic G-decompositions of K_{2n+1} while other stricter labelings yielded cyclic G-decompositions of K_{2nx+1} for all natural numbers x. We investigate the labelings of various classes of 3-regular (cubic) graphs and report on our results. (Received September 22, 2010)

1067-05-2226 **Emily Berger*** (erb90@mit.edu). *Minimal Percolating Sets in the Hypercube and Related Graphs.*

We study the extremal problem of finding the minimal size of a percolating set in the hypercube, the square of the hypercube, and the augmented hypercube. Consider the following process of bootstrap percolation on a graph G. Let $S \subset V(G)$ denote a set of initially infected vertices. Throughout this process, some $v \in V(G)$ becomes infected only if it has r previously infected neighbors. We say S is an r-percolating set if all of $V(G)$ becomes infected by this process. We study, for fixed $r \geq 3$, how the size of a minimal r-percolating set varies with the dimension of G; this process is well understood for $r < 3$. We provide asymptotic bounds and exact values in some cases. (Received September 22, 2010)

1067-05-2227 **Christian Pawlak*** (ckpawla@ilstu.edu), Mathematics Department, Illinois State University, Normal, IL 61790-4520, and **Krystal Brewington**, **Jessica Lynn Smith** and **Stephanie Zeppetello**. *On Cyclic G-designs, where G is the one-point union of two cycles.*

Let G be the graph consisting of two cycles that share a single vertex and let n be the number of edges of G. We show that there exists a cyclic G-decomposition of K_{2nx+1} for every positive integer x. (Received September 22, 2010)

1067-05-2261 **Jobby Jacob*** (jxjsma@rit.edu). *Graph Labeling with Distance-Two Constraints.*

The channel assignment problem is the problem of assigning radio frequencies to transmitters while avoiding interference. This problem can be modeled and examined using graphs and graph colorings. $L(2,1)$ coloring was first studied as a model of a variation of the channel assignment problem. An $L(2,1)$ coloring of a graph is a vertex labeling f such that $|f(u) - f(v)| \geq 2$ if u and v are adjacent and $|f(u) - f(v)| \geq 1$ if $d(u,v) = 2$. A no-hole $L(2,1)$ coloring is defined to be an $L(2,1)$ coloring which uses all the colors $\{0, 1, \ldots, k\}$ for some integer k. An $L(2,1)$ coloring is irreducible if no vertex labels can be decreased and yield another $L(2,1)$ coloring. A graph G is inh-colorable if there exists an irreducible no-hole coloring on G.

We will discuss the inh-colorability of certain classes of graphs. (Received September 22, 2010)

1067-05-2277 **Crystal L. Bennett*** (clbennet@ncat.edu), 1401 Cunningham Street, Unit D, Greensboro, NC 27401, and **Joshua Chukwuka** and **Kenneth Berg** (krb@math), Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742. *Winning strategy for Chomp Grid with 0, 1, 2, or 3 pieces in the 3rd row.*

The objective of this summer REU project portion is to design and implement a winning strategy for chomp grid with up to three pieces in the 3rd row. The take-away game Chomp is played on a rectangular grid with m number of rows and n number of columns. The grid is divided into squares. Two players alternate removing pieces from the grid. The lower right hand piece is poison and the player who removes this piece loses. By expanding the standard version of Chomp of 2 rows and 5 columns to 3 rows and indefinitely many columns, we would like to investigate if we can come up with a way to find all the losing positions of a chomp grid when there are 3 rows and 0, 1, 2, or 3 pieces in the top row. Losing positions are members of the set L. All other positions are considered winning and a member of the set W. If a player can force the game to alternate from a position in W to a position in L and back to a position in W making the game go "W, L, W, L", the other player will lose. We have developed theorems for common conditions in chomp so that the player can manipulate the game as such. (Received September 22, 2010)

1067-05-2294 **Ji Young Choi*** (jychoi@ship.edu). *Minimum P_k-total weights of graphs.* Preliminary report.

For a positive integer k, the P_k-total weight for a ± 1-edge assigned graph G is the absolute value of the sum of the weights for every possible non-cyclic path of length k. The minimum P_k-total weight of a graph G is defined as the minimum of the P_k-total weight of G, considering every possible ± 1-edge assignment. This talk presents the minimum P_k-total weights for several simple connected graphs to find its bounds and the sufficient conditions for 0 minimum P_k-total weight. (Received September 22, 2010)

1067-05-2295 **Christian Joseph Altomare*** (altomare@math.ohio-state.edu), 231 West 18 Avenue, Columbus, OH 43210. *Unifying Laver's Theorem and the Graph Minor Theorem via Proof System Minors.*

The famous Graph Minor Theorem states that in every infinite sequence of finite graphs, one is a minor of another. In other words, finite graphs are well quasi ordered under the minor relation. The similarly famous Laver's Theorem states that total orders not containing the rationals are well quasi ordered under embedding. Though minors of graphs and embeddings of total orders at first seem incongruous, we shall see that proof system minors put them on the same footing. Proof system minors generalize graph (and matroid) minors as well as total order embeddings. Further, they allow us to pose a conjecture generalizing both the Graph Minor Theorem and the countable case of Laver's Theorem. (Received September 22, 2010)

1067-05-2297 **Torina Deachune Lewis*** (tdlewis1@olemiss.edu), **Talmage James Reid** and **Laura Sheppardson**. *Bicircular Matroids with Circuits of a Single Size.*

Murty was was the first to study matroids with all hyperplanes having the same size in his paper, equicardinal matroids and fnite geometries. Young renamed such a matroid a "Matroid Design". Further work on determining properties of these matroids was done by Peyton Young, U. S. R. Murty, and Jack Edmonds in thier paper, equicardinal matroids and matroid-designs. These authors were able to connect the problem of determining such a matroid with problems on balanced incomplete block designs. The dual of a matroid design is one in which all circuits have the same size. Murty restricted his attention to binary matroids and was able to characterize all connected binary matroids having circuits of a single size. Lemos, Reid, and Wu provided partial information on the class of connected binary matroids having circuits of two different sizes. They also showed that there are many such matroids. Here we determine the connected bicircular matroids with all circuits having the same size. (Received September 22, 2010)

1067-05-2312 **Amin Bahmanian** and **Dan Roberts*** (dpr0003@auburn.edu), Dept. of Mathematics and Statistics, Auburn, AL 36849-5310. *On Hyperstar Decompositions of Hypergraphs.*

A hypergraph $G = (X, \mathcal{E})$ is a *hyperstar* with center C if $C \subseteq \bigcap_{E \in \mathcal{E}} E$. The *size* of G is $|\mathcal{E}|$ and we say that G has *center size* $|C|$. We find necessary and sufficient conditions for complete uniform hypergraphs and complete hypergraphs to be decomposed into $S_{m_1}, \ldots, S_{m_\ell}$ where S_{m_i} is a hyperstar of size m_i with center size 1. (Received September 22, 2010)

1067-05-2322 **Thomas Langley*** (`langley@rose-hulman.edu`), Rose-Hulman Institute of Technology, Department of Mathematics, CM144, 5500 Wabash Ave., Terre Haute, IN 47803, and **Jeffrey Remmel**, University of California, San Diego. *Enumerating embeddings under generalized factor orders.* Preliminary report.

Given a partially ordered set P, an embedding of a word u into a word w under generalized factor order relative to P is a subword v of w, of the same length as u, such that each character of v is greater than or equal to its corresponding character of u under the ordering of P. Recent work has resulted in generating functions for words that embed a fixed word under various generalized factor orders over the positive integers, with counters for the length of a word and the sum of the characters of a word. We explore methods to add a counter for the number of embeddings, as well. (Received September 22, 2010)

1067-05-2342 **David S. Rolnick*** (`drolnick@mit.edu`). *On-line Degree Ramsey Numbers: Building and Painting Graphs, One Edge at a Time.*

On-line Ramsey theory studies a graph-building game between two players. The player called Builder builds edges one at a time, and the player called Painter paints each new edge red or blue after it is built. The graph constructed is called the *background graph*. Builder's goal is to cause the background graph to contain a monochromatic copy of a given *goal graph*, and Painter's goal is to prevent this. In an S_k*-game*, the background graph is constrained to have maximum degree no greater than k. The on-line degree Ramsey number $\mathring{R}_\Delta(G)$ of a graph G is the minimum k such that Builder wins an S_k-game in which G is the goal graph.

Butterfield et al. classified the graphs G satisfying $\mathring{R}_\Delta(G) \leq 3$, but $\mathring{R}_\Delta(G)$ is unknown for virtually all other G. We present the following results:

(1) Completion of the investigation begun by Butterfield et al. into the values $\mathring{R}_\Delta(C_n)$. We show that $\mathring{R}_\Delta(C_n) = 4$ for all $n \geq 3$.

(2) Classification of the trees T such that $\mathring{R}_\Delta(T) = 4$.

(3) Identification of various examples of graphs G which are neither trees nor cycles and which satisfy $\mathring{R}_\Delta(G) = 4$. These are the first such graphs to be identified.

(Received September 22, 2010)

1067-05-2373 **Neil Robertson*** (`robertso@math.ohio-state.edu`). *On graph well-quasi-order by topological inclusion.*

Graph well-quasi-order (wqo) goes back to Vazsonyi, who conjectured in the 1930's that trees under topological inclusion have the property that for any infinite sequence T(1), T(2), ... of trees, indices i, j exist with T(i) topologically included in T(j). This talk considers the general problem of when a topologically closed class of graphs is a wqo. The conjecture for trees was proved by J. Kruskal in the 1950's and the conjecture for subcubic graphs is a corollary of the graph minor wqo theorem from the 1980's. (Received September 22, 2010)

1067-05-2374 **Janet L. Fierson*** (`janet.fierson@usma.edu`). *Some graph theoretical results for the task mapping problem for parallel computers.* Preliminary report.

Today, massively parallel systems of thousands of processors are being utilized on a regular basis to tackle large-scale problems in a wide variety of fields such as biology, economics, and linguistics. Task mapping, or the assignment of tasks to processors, plays a central role in determining how efficiently solutions may be found. Tasks are the sub-problems into which an application has been decomposed; processors are the individual computing elements of a parallel system.

Both networks and applications may be viewed as graphs. A network may be represented by a processor communication graph, with vertices representing processors and edges representing direct physical connections between processors. An application may be represented by a task interaction graph, with vertices representing tasks and weighted edges representing the amount of communication necessary between tasks. We study some related problems in graph theory for specific classes of graphs. In particular, we consider families representative of common computer architectures. In addition to investigating properties of these graphs and presenting theoretical results, we discuss the practical relevance of our results with regard to task mapping. (Received September 22, 2010)

1067-05-2387 **Guven Yuceturk*** (`yucetgu@auburn.edu`), 221 Parker Hall, Auburn University, Auburn, AL 36849, and **Hoffman G. Dean** (`hoffmdg@auburn.edu`), 133C Allison Lab, Auburn University, Auburn, AL 36849. *Gregarious Path Decompositions of Some Graphs.*

Let G be a simple graph and $f(v)$ a positive integer for each vertex v of G. Form G^f by replacing each v by a set $F(v)$ of $f(v)$ vertices, and each edge uv by complete bipartite graph on bipartition $(F(u), F(v))$. Can we partition G^f into paths of length 2 which are *gregarious*, that is, meet three different $F(u)$'s? Keywords: gregarious, path, graph decomposition (Received September 23, 2010)

1067-05-2388 **Christopher J Stocker*** (stocker2@illinois.edu), 1409 W. Green Street, Urbana, IL 61801, and **Alexandr V Kostochka** (kostochk@math.uiuc.edu) and **Peter Hamburger** (peter.hamburger@wku.edu). *Packing sparse hypergraphs.*

Two hypergraphs G and H on n vertices are said to *pack* if there exists a bijection $\sigma : V(G) \to V(H)$ such that for every edge e in G, $\sigma(e)$ is not an edge in H. Proving a conjecture by Milner and Welsh, Sauer and Spencer showed that any two n-vertex graphs G and H with $|E(G)| + |E(H)| < \frac{3n-2}{2}$ pack. The bound $\frac{3n-2}{2}$ is sharp. We extend this result to hypergraphs containing no edges of size 1 and $n-1$. (Received September 23, 2010)

1067-05-2413 **Guantao Chen*** (gchen@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303, **Manzhan Gu**, Department of Applied Mathematics, Shanghai University of Finance and Economics, Shanghai, Peoples Rep of China, and **Nana Li**, Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *On Maximum Cuts of Connected Digraphs.* Preliminary report.

Let $D = (V, E)$ be a digraph with a vertex set V and an edge set E. A set $C \subseteq E$ is called a directed cut of D if there is a partition (X, Y) of V such that $C = \{\vec{xy} \in E \ : \ x \in X \text{ and } y \in Y\}$, that is, C consists of all directed edges from X to Y . Let $D(1,1)$ denote the set of digraphs D such that for each vertex v either $d^+(v) \leq 1$ or $d^-(v) \leq 1$, where $d^+(v)$ and $d^-(v)$ are the outdegree and indegree of v, respectively. Clearly, all digraphs with maximum degree at most 3 are in $D(1,1)$. We show that every connected graph of m edges in $D(1,1)$ contains a directed cut of size at least $(3/8)m - 1/8$, which provides a positive answer to a problem of Lehel, Muffray and Presissman. We also give a negative answer to their another problem: If a connected digraph $D \in D(1,1)$ with m edges contains no directed triangles and has s vertices v with $d^+(v) \cdot d^-(v) = 0$, then D contains a directed cut of size at least $(2m + s)/5$. (Received September 23, 2010)

1067-05-2416 **Xingxing Yu***, School of Mathematics, Georgia Tech, Atlanta, GA 30332, and **Jie Ma**, School of Mathematics, Georgia Tech, Atlanta, GA 30332. *K_5-subdivisions in 5-connected nonplanar graphs.*

Kuratowski's theorem states that a graph is planar iff it contains no subdivision of K_5 or $K_{3,3}$. Seymour and independently Kelmans conjectured in the 1970s that every 5-connected nonplanar graph contains a subdivision of K_5. We show that this is ture when the graph contains K_4^- as a subgraph. We also show that why excluding K_4^- is useful. Joint work with Jie Ma. (Received September 23, 2010)

06 ► Order, lattices, ordered algebraic structures

1067-06-528 **Philip Ehrlich*** (ehrlich@ohio.edu), Department of Philosophy, Ohio University, Athens, OH 45701. *Surreal Ordered Exponential Fields.*

J. H. Conway's ordered field No of surreal numbers has a rich algebraico-tree-theoretic structure, or simplicity hierarchy, that emerges from the recursive clauses in terms of which it is defined. This simplicity-hierarchical structure is central to No's structure as an ordered exponential field. Among the striking simplicity-hierarchical features of No is that much as the surreal numbers emerge from the empty set of surreal numbers by means of a transfinite recursion that provides an unfolding of the entire spectrum of "numbers great and small," the recursive process of defining No's arithmetic in turn provides an unfolding of the entire spectrum of ordered number fields in such a way that an isomorphic copy of every such system either emerges as an initial subtree of No or is contained in a theoretically distinguished instance of such a system that does. In particular, every real-closed ordered field is isomorphic to a recursively generated initial subfield of No. In the present talk we will draw attention to some of the exponential ordered fields that likewise emerge as recursively defined initial subfields of No. (Received September 14, 2010)

1067-06-542 **Michelle Knox*** (michelle.knox@mwsu.edu), Department of Mathematics, Midwestern State University, Wichita Falls, TX 76308. *Questions of Divisibility in a Group of Density Continuous Functions.*

Let $A(\mathbb{R})$ denote the group (under composition) of order-preserving permutations of $\mathbb{R}$, i.e., the set of increasing bijections $f : \mathbb{R} \to \mathbb{R}$. Let $\mathbb{R}_d$ denote the real numbers with the density toplogy, and let $\mathcal{H}$ denote the subgroup of $A(\mathbb{R})$ of increasing density continuous bijections $f : \mathbb{R}_d \to \mathbb{R}_d$. It is known that $A(\mathbb{R})$ is divisible, that is, for every $n \in \mathbb{N}$ and $g \in A(\mathbb{R})$ there exists $h \in A(\mathbb{R})$ such that $h^n = g$. We begin our investigation of when $\mathcal{H}$ is divisible by considering the simpler case of piecewise linear functions. (Received September 08, 2010)

1067-06-661 **Gerald A Edgar*** (edgar@math.ohio-state.edu), 231 W Eighteenth Ave, Department of Mathematics, Columbus, OH 43210. *Transseries: Composition, Recursion, and Convergence.*

The set $\mathbb{T}$ of transseries is naturally provided with additional structure. It is an ordered field. It is real-closed. It is a proper extension of the reals. And it has many additional operations, including exponential, logarithm, derivative, composition. Once the basic construction is given, many of the basic properties are easily established. But there are some basic properties that deal with composition where (so far at least) I do not know easy proofs. One example: Let T, S_1, S_2 be transseries. Assume S_1, S_2 are large and positive, $S_1 < S_2$. If $T' > 0$, then $T \circ S_1 < T \circ S_2$. (Received September 13, 2010)

1067-06-663 **Jeremiah William Johnson*** (jwj10@psu.edu), Penn State Harrisburg, W-255 Olmsted, 777 W. Harrisburg Pike, Middletown, PA 17057. *Admissible Orders on Quotients of the Free Associative Algebra.*

An admissible order on a multiplicative basis of a noncommutative algebra is a term order satisfying additional conditions that allow for the construction of Gröbner bases. E. Hinson has used position-dependent weights encoded in so-called *admissible* arrays to partially order words in the free associative algebra in a way which produces a length-dominant admissible order on a particular quotient of the free algebra. The ideal by which the quotient is taken, the so-called *weight ideal*, is generated by pure homogeneous binomial differences and is determined by the array.

In this talk I will discuss the weight ideals associated to two families of admissible arrays. The weight ideals associated to an array in the first class is finitely generated and we can describe its generating set. The weight ideals associated to arrays in the second class may be trivial, may be nontrivial but finitely generated, or may not admit a finite generating set. (Received September 13, 2010)

1067-06-1159 **Papiya Bhattacharjee*** (pxb39@psu.edu). *The spaces $Min(L)$ and $Min(L)^{-1}$.*

A frame is a complete lattice which satisfies a strong distributive law, also called the 'frame law'. Some examples of frames are the following: For any topological space (X, τ), the collection of all open subsets, τ, is a frame under inclusion; For a commutative ring A with identity, $Rad(A)$, the collection of all radical ideals, is a frame under inclusion; For a lattice-ordered group G, $\mathcal{C}(G)$, the collection of all convex lattice-ordered subgroups, is a frame under inclusion.

Given a frame L, the collection of all minimal prime elements of L can be equipped with two topologies, namely, the Zariski topology (denoted by $Min(L)$) and the inverse topology (denoted by $Min(L)^{-1}$). In this talk the speaker will describe these two topologies and give conditions on L for the spaces $Min(L)$ and $Min(L)^{-1}$ to have various topological properties, for example, compact, locally compact, Hausdorff, and zero-dimensional. Finally, if time permits, the speaker will discuss the application of the various frame-theoretic conditions to commutative ring theory. (Received September 19, 2010)

1067-06-1493 **Adam Grabowski*** (adam@math.uwb.edu.pl), Institute of Mathematics, University of Bialystok, ul. Akademicka 2, 15-663 Bialystok, Poland. *Formalization of Lattice Theory in Mizar.*

Lattice theory is one of the fields of mathematics where the idea of computer-supported formal proof was made available for wider audience rather early - if we take into account the proof of the Robbins' conjecture about conditions which make near-Boolean algebras Boolean. Although the original proof (generated by EQP/Otter theorem prover) was not easily understandable for a human at first glance, many attempts, also computer driven, were made to make it more readable. Also within the Mizar Mathematical Library, considered one of the largest repositories of computerized mathematical knowledge, the formalization of this old problem caused quite a few modifications of the existing net of mathematical structures. Now it is possible to translate proof steps produced by automated theorem provers, the question is how to represent the underlying data structure to make it more accessible to mathematicians. In this talk I will present a summary of the development of lattice theory, illustrated also by examples from the rough set theory. (Received September 21, 2010)

08 ► General algebraic systems

1067-08-326 **Paige E Rinker*** (paige.rinker@dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755. *Cluster Analysis of Data on Finite Groups and Homogeneous Spaces.* Preliminary report.

Generally, the goal of cluster analysis is to uncover commonalities and patterns in large data sets; for rank or voting data, we seek to group similar observed rankings and identify rankings that are prototypical representatives for each group. In 2007, Busse, Orbanz and Buhmann pioneered a new method for the analysis of particular kinds of ranking data. They focused their attention to data on a combination of complete rankings and so-called "top-t" rankings. Here, we introduce an efficient method for performing cluster analysis of general rank data (i.e. data on combinations of the symmetric group, $\mathbb{S}_n$, and its quotients), and extend this method to data on other finite groups and their homogeneous spaces which arise naturally in a variety of settings. (Received September 21, 2010)

1067-08-859 **Ya-lun Tsai*** (tsaix066@umn.edu). *Real root counting for parametric polynomial systems and applications to Maxwell's conjecture.*

James C. Maxwell conjectured there are at most 4 non-degenerated equilibrium points of the electric potential created by 3 point charges. Fixing a configuration that 3 point charges form, we reduce the problem to counting positive zeros of a system with 2 polynomial equations in 2 variables and 2 parameters.

Using Groebner basis to compute Hermite quadratic forms makes it possible to count positive zeros of real polynomial systems. We extend the usages of these tools to work for parametric polynomial systems. Together with Sylvester resultants and subresultant sequences, we are able to count positive zeros of our polynomial systems for all nonzero real pairs of parameters. Therefore, we prove that Maxwell's conjecture is true in the case when there are 3 point charges forming an equilateral triangle. (Received September 15, 2010)

1067-08-1102 **John H. Johnson*** (johnsojh@dukes.jmu.edu). *J-sets in Commutative and Uncommutative Semigroups.*

A J-set in $\mathbb{N}$ enjoys an easily derived combinatorial property:

> Given a sequence $\langle x_n \rangle_{n=1}^{\infty}$ in $\mathbb{N}$, a J-set in $\mathbb{N}$ contains arbitrarily long arithmetic progressions with difference from $\{\sum_{n\in F} x_n : \emptyset \neq F \subseteq \mathbb{N} \text{ is finite}\}$.

It's also a (not so easily derived) fact that every set with positive upper density is a J-set in $\mathbb{N}$. The notion of a J-set makes sense in any semigroup, and it is from this context we will look at J-sets. In this talk we will show the following result.

> **Proposition.** *Let S be a commutative semigroup, $T \subseteq S$ a subsemigroup, and $A \subseteq T$. If A is a J-set in S, then A is a J-set in T.*

We will also show that this Proposition is false when the commutativity assumption is dropped. (Received September 18, 2010)

1067-08-1739 **Paige E. Rinker*** (paige.rinker@dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755. *Cluster Analysis of Heterogeneous Data on Rankings and Flags.* Preliminary report.

In 2007, Busse, Orbanz and Buhmann devised an efficient method for performing cluster analysis of particular kinds of ranking data. Their work focuses on data comprised of a mixture of complete rankings and "top-t" partial rankings, where t is allowed to vary. Here, we extend their method to partial rankings of arbitrary type and go on to describe a similar approach for cluster analysis of data on the flag variety for $GL_n(\mathbb{F}_q)$. (Received September 21, 2010)

1067-08-1873 **Alex Zhai*** (zhai@fas.harvard.edu). *An Asymptotic Result on the Wilf Conjecture.*

Let Λ be a numerical semigroup, i.e. a cofinite subsemigroup of the non-negative integers, generated by k generators. The Wilf conjecture states that if we define $c(\Lambda) = \max(\mathbb{N} \setminus \Lambda) + 1$ and $c'(\Lambda) = |\Lambda \cap [0, c(\Lambda) - 1]|$, then $\frac{c'(\Lambda)}{c(\Lambda)} \geq \frac{1}{k}$. We prove the slightly weaker bound $\frac{c'(\lambda)}{c(\Lambda)} \geq \frac{1}{k} - \frac{m(\Lambda)}{2c(\Lambda)}$, where $m(\Lambda)$ is the smallest non-zero element of Λ. As a corollary, we find that for fixed k and any $\epsilon > 0$, the bound $\frac{c(\Lambda)}{c'(\Lambda)} \geq \frac{1}{k} - \epsilon$ holds for all but finitely many Λ. This result seems to be a step towards proving the Wilf conjecture, as most previous bounds focused on special cases. Finally, we discuss intuitive reasons for why the Wilf conjecture should hold and how our bounds might be improved. (Received September 22, 2010)

11 ► Number theory

1067-11-11 **Akshay Venkatesh***, Department of Mathematics, Stanford University, Stanford, CA. *Modular forms and the topology of certain hyperbolic 3-manifolds.*

I'll discuss questions, suggested by modular forms, about the topology of certain ("arithmetic") hyperbolic 3-manifolds. The questions will mainly relate to the first homology group, and in particular its torsion part; I will give lots of examples. Results presented are from joint works with Nicolas Bergeron and Frank Calegari. (Received September 23, 2010)

1067-11-14 **Alexander Lubotzky*** (alexlub@math.huji.ac.il), The Hebrew University of Jerusalem, Jerusalem, Israel. *Expander graphs in pure and applied mathematics, II.* Preliminary report.

Till the mid 90's essentially all the work on expander graphs was done by computer scientists who used them for various applications and by pure mathematicians who took the challenge of using deep mathematical theories to provide the computer scientists with better and better expanding graphs (e.g. the so-called Ramanujan graphs).

In the last 13 years, CS started to pay back its debt ... Expander graphs have started to play an increasing role in pure mathematics - in geometry, group theory and number theory.

In the 2nd talk we will present some of these applications to number theory and group theory. Most notably is the "affine sieve method", promoted by Sarnak. This is a far reaching extension and a non-commutative version of Dirichlet theorem on primes in arithmetic progressions. The recent works of Helfgott, Bourgain, Breuillard, Green, Tao, Pyber, Szabo, Salehi-Golsedify and Varju brought this method to a quite satisfactory point, with various entertaining applications, such as appolonian circles and more.

An even more recent application is adapting analogous sieve methods to the study of purely group theoretical problems on arithmetic groups, linear groups and the mapping class groups. (Received September 16, 2010)

1067-11-33 **Maxwell Anselm*** (mba210@lehigh.edu) and **Steven H Weintraub** (shw2@lehigh.edu). *A Generalization of Continued Fractions.*

We consider a generalization of continued fractions, where the 1 in the "numerator" of the continued fraction is replaced by an arbitrary positive integer N. We refer to this as a cf_N expansion. The algorithm for cf_1 expansions (i.e., classical continued fractions) generalizes to cf_N expansions. Also, there is a natural notion of a *best* cf_N expansion.

Theorem 1. *For $N > 1$, every positive irrational number has infinitely many cf_N expansions and infinitely many of these expansions are nonperiodic. For $N > 1$, every positive rational number has infinitely many finite cf_N expansions. For $N > 2$, every positive rational number has infinitely many periodic cf_N expansions and infinitely many nonperiodic cf_N expansions.*

Conjecture 2. *For $N > 1$, the best cf_N expansion of a quadratic irrationality is not always periodic.*

We also consider the relationship between the best cf_N expansion of $\sqrt{E}$ and solutions to Pell's equation $x^2 - Ey^2 = 1$, where we find that the relationship is considerably more involved than in the classical case.

(This work is the first author's Senior Honors Thesis at Lehigh University, written under the direction of the second author.) (Received June 08, 2010)

1067-11-111 **Kevin J. McGown*** (kmcgown@math.ucsd.edu), Department of Mathematics, Oregon State University, 368 Kidder Hall, Corvallis, OR 97331. *Norm-Euclidean Galois cubic fields.*

Assuming the Generalized Riemann Hypothesis, I have given a complete determination of all norm-Euclidean Galois cubic fields. The proof uses a combination of algebraic, analytic, and computational techniques. I will also discuss what can be proven unconditionally. (Received July 23, 2010)

1067-11-113 **Joseph H Silverman*** (jhs@math.brown.edu), Mathematics Department - Box 1917, Brown University, Providence, RI 02912. *Lehmer's conjecture and points on elliptic curves that are congruent to torsion points.* Preliminary report.

Lehmer's conjecture says that if $\alpha \in \overline{\mathbb{Q}}$ is not a root of unity, then its height satisfies $h(\alpha) \geq C/D(\alpha)$, where C is an absolute constant and $D(\alpha) = [\mathbb{Q}(\alpha) : \mathbb{Q}]$. In addition to being of theoretical interest, height estimates of this sort are used to determine termination conditions for various search algorithms. Borwein, Dobrowolski and Mossinghoff have shown that if the minimal polynomial $F_\alpha(X)$ of α is congruent modulo m to $1 + X + X^2 + \cdots + X^{D(\alpha)}$, then the height of α satisfies a Lehmer bound of the form $h(\alpha) \geq (C \log m)/D(\alpha)$. Interpreting the congruence as saying that the conjugates of α are congruent to roots of unity, we formulate and prove an elliptic curve analogue of the [BDM] result. (Received July 24, 2010)

1067-11-128 **Aliza A Steurer*** (asteurer@dom.edu), Dominican University, 7900 W. Division, River Forest, IL 60305. *Using the p-Group Generation Algorithm to Determine Extensions of D_4 by $C_2 \times C_2 \times C_{2^n}$.* Preliminary report.

Let p be a prime and let D_4 represent the dihedral group of order 8. Michael Bush used the p-group generation algorithm to determine possible presentations for the Galois groups of the maximal unramified 2-extensions of several imaginary quadratic fields. His work with $\mathbb{Q}(\sqrt{-445})$, $\mathbb{Q}(\sqrt{-1015})$, and $\mathbb{Q}(\sqrt{-1595})$ led us to discover that their Galois groups are members of a larger family of group extensions of D_4 by $C_2 \times C_2 \times C_{2^n}$ with respect to a certain action. Using Magma, we conjectured that for each $n \geq 3$, there are 8 distinct such extensions of D_4 by $C_2 \times C_2 \times C_{2^n}$. Furthermore, these 8 groups appear to form 4 pairs such that the groups in each pair have isomorphic subgroup lattices and under this isomorphism, corresponding proper subgroups and quotients are isomorphic. Thus, distinguishing these groups is quite difficult. In this talk, we will discuss how we are currently utilizing the p-group generation algorithm by hand to compute presentations for these extensions and thereby prove our conjecture. (Received July 26, 2010)

1067-11-158 **Steven E Duff*** (sed020@bucknell.edu), 17 Indiana Avenue, Sinking Spring, PA 19608, and **Nathan C Ryan** (nathan.c.ryan@gmail.com). *A Statistical Look at the Gauss-Kuzmin Distribution.* Preliminary report.

The Gauss-Kuzmin distribution predicts the distribution of terms in the continued fraction expansion of almost all real numbers. Unfortunately, it provides no characterization of the set of full measure for which the distribution holds. Finding elements contained in this set would tell us more about this set and about continued fractions in general. We develop a framework for experiments to determine if a number is contained in the set of full measure. An important part of describing this framework is developing and implementing algorithms that generate random continued fraction expansions. (Received July 28, 2010)

1067-11-204 **Amara Chandoul*** (amarachandoul@yahoo.fr), Sfax, Tunisia. *On periodic Jacobi-Perron algorithm over formal power series field.* Preliminary report.

In this paper we are able to prove that over any formal power series field extension of degree $n+1$, $\mathbb{F}_q[X][\rho]$, there is a vector $(\omega_1, \ldots, \omega_n)$ in $(\mathbb{F}_q[X][\rho])^n$, witch is periodic by the Dubois version of the Jacobi-Perron algorithm. we prove also that there is no algebraic formal series ω such that the vector (ω, ω^2) is 2-purely periodic by the homogenous version of Jacobi-Perron algorithm and we give a characterization of vector (ω, ω^2) which is 1 and 3-purely periodic by it. We conjecture that this result holds for $2n$ and $2n+1$. (Received August 03, 2010)

1067-11-210 **Jodi A. Black*** (jablack@emory.edu), Emory University, Mathematics and Science Center, 400 Dowman Drive, Suite W401, Atlanta, GA 30322. *Zero Cycles of Degree One on Principal Homogeneous Spaces.*

Let G be an adjoint or simply connected, semisimple, classical algebraic group defined over a field k of characteristic different from 2 and let X be a principal homogeneous space under G over k. We show that if X admits a zero cycle of degree 1 then X has a k-rational point. (Received August 04, 2010)

1067-11-214 **Mitsuo Kobayashi***, Mathematics and Statistics Department, 3801 West Temple Avenue, Pomona, CA 91768. *On the density of abundant numbers.* Preliminary report.

A natural number is called abundant if the sum of its proper divisors does not exceed the number itself. The set of abundant numbers has a positive asymptotic density which has been calculated by Deléglise to be about 0.247. By making some improvements in his method I recently found the density to be about 0.2476. Another natural approach to compute this density is to consider "primitive" members of the sequence, namely those not divisible by any smaller member, and then consider their multiples. However the inclusion–exclusion inherent here threatens to explode. In this talk I will show how to control this explosion to yield a different viable method for computing the density of the abundants. (Received August 05, 2010)

1067-11-221 **Dae San Kim*** (dskim@sogang.ac.kr), Department of Mathematics, Sogang University, Seoul, 121-742, South Korea, and **Kyoung Ho Park** (sagamath@yahoo.co.kr), Department of Mathematics, Sogang University, Seoul, 121-742, South Korea. *Identities of symmetry for Bernoulli polynomials.*

In this paper, we derive eight basic identities of symmetry in three variables related to Bernoulli polynomials and power sums. These and most of their corollaries are new, since there have been results only about identities of symmetry in two variables. These abundance of symmetries shed new light even on the existing identities so as to yield some further interesting ones. The derivations of identities are based on the p-adic integral expression of the generating function for the Bernoulli polynomials and the quotient of integrals that can be expressed as the exponential generating function for the power sums. (Received August 08, 2010)

1067-11-260 **Bei Zhang*** (zbtai@math.northwestern.edu), 914 A Crain Street, Apt 2S, Evanston, IL 60202. *Fourier-Jacobi coefficients of Eisenstein series on unitary group and the application in Iwasawa main conjecture.*

In this talk, I will explain my work about the calculation of the Fourier-Jacobi expansion of Eisenstein series on $U(3,1)$, or more generally on any non quasi-split unitary group. I relate the Fourier-Jacobi coefficient of the Eisenstein series with special values of L-functions. It can help verify the existence of certain p-integral Eisenstein series on $U(3,1)$ which does not vanish modulo p. This is a crucial step towards the main conjecture for $GL_2 \times K^\times$ using Eisenstein congruence method. (Received August 14, 2010)

1067-11-284 **Becky E Hall*** (hallb@wcsu.edu), 181 White Street, Danbury, CT 06810. *An Improved Method for Computing Group Homology of the Congruence Subgroup $\Gamma_0(2)$ of $SL_3(\mathbb{Z})$.*

A well-known theorem due to Manin gives a relationship between modular symbols for a congruence subgroup $\Gamma_0(N)$ of $\mathrm{SL}_2(\mathbb{Z})$ and the homology of $X_0(N)$. A corresponding theorem for congruence subgroups of $\mathrm{SL}_3(\mathbb{Z})$ was made by Avner Ash. I will briefly discuss an improved method for computing the group homology of the congruence subgroup $\Gamma_0(2)$ of $\mathrm{SL}_3(\mathbb{Z})$. For W a $\Gamma_0(2)$-module, I identify the group homology of $\Gamma_0(2)$ with a subspace of W^7. This method uses a generalized notion of Gröbner bases in order to determine a minimal generating set for the ideal of conditions describing the desired subspace of W^7. This procedure can be extended to $\Gamma_0(N)$ for $N > 2$. (Received August 16, 2010)

1067-11-330 **Renate Scheidler*** (rscheidl@ucalgary.ca), Department of Mathematics & Statistics, University of Calgary, 2500 University Drive NW, Calgary, AB T2N1Z4, Canada, and **Roberto Avanzi**, **Michael J Jacobson, Jr.** and **Andreas Stein**. *Efficient Divisor Reduction on Hyperelliptic Curves.*

A key ingredient in hyperelliptic curve arithmetic is divisor reduction. Standard reduction methods take as input a non-reduced divisor in Mumford representation and iteratively generate a sequence of divisors until a reduced one is obtained. In this computationally expensive process, the degrees of the intermediate Mumford coefficients gradually decrease down to the genus of the curve. This talk will illustrate how to replace this costly procedure by the computation of just two linear recurrences which allow the recovery of the Mumford polynomials of the reduced target divisor at the end. The two scenarios under consideration are a large input divisor that could have been obtained via an inexpensive tupling procedure for example, and an input divisor that is the sum of two reduced divisors, as encountered in scalar multiplication using non-adjacent form. (Received August 23, 2010)

1067-11-331 **Renate Scheidler*** (rscheidl@ucalgary.ca), Department of Mathematics & Statistics, University of Calgary, 2500 University Drive NW, Calgary, AB T2N1Z4, and **Kell H. F. Cheng**, **Richard K. Guy** and **Hugh C. Williams**. *Classification and Symmetries of a Family of Continued Fractions With Bounded Period Length.*

It is well-known that the continued fraction expansion of a quadratic irrational is symmetric about its centre; we refer to this symmetry as horizontal. However, an additional vertical symmetry is exhibited by the continued fraction expansions arising from a certain one-parameter family of positive integers known as Schinzel sleepers. This talk provides a method for generating any Schinzel sleeper and investigates their period lengths as well as both their horizontal and vertical symmetries. (Received August 23, 2010)

1067-11-348 **Kevin G. Hare*** (kghare@math.uwaterloo.ca), Dept of Pure Math, University of Waterloo, Waterloo, Ontario N2T 2L1, Canada, and **Michael Mossinghoff**. *Pisot and Salem polynomials dividing Newman polynomials.*

We say $p(x)$ is a *Newman polynomial* if $p(x) = a_n z^n + \cdots + a_0$ for some $a_i \in \{0, 1\}$. It is known that if $f(x)$ is an integer polynomial with a negative root larger than the golden ratio in magnitude, that $f(x)$ cannot divide a Newman polynomial. The inverse question is interesting. Under what condition on $f(x)$ can we say that $f(x)$ does divide a Newman polynomial. In this talk we will discuss this question, as it pertains to the minimal polynomials of Pisot and Salem numbers. (Received August 25, 2010)

1067-11-358 **Alejandra Alvarado*** (alvarado@math.arizona.edu), 617 N. Santa Rita Ave., Tucson, AZ 85721. *Arithmetic Progressions in the y-coordinates of Certain Elliptic Curves.*

We consider arithmetic progressions in the y-coordinate on the elliptic curve $y^2 = x^3 + k$ whose coefficients are rational. We investigate lengths four, five, and six. (Received August 26, 2010)

1067-11-362 **Omer Yayenie*** (omer.yayenie@murraystate.edu), 6C-1 Faculty Hall, Murray, KY 42071. *A Note on the Power Subgroups of the Modular Group.*

Let $\Gamma(1)$ be the inhomogeneous modular group and let $\Gamma(1)^n$ be a power subgroup of the modular group generated by the n^{th} power of elements of $\Gamma(1)$. These subgroups are known when $gcd(n, 6) < 6$ or $n = 6k$ for $k = 1$ or $k \geq 72$. There are 70 cases where these subgroups are unknown, namely $\Gamma(1)^{6m}$ for $2 \leq m \leq 71$. In this article we give a brief summary of these subgroups and provide some new results that might lead to the classification of these unknown power subgroups.
(Received August 27, 2010)

1067-11-374 **Nigel Boston*** (boston@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53705. *Combining Group Theory and Number Theory Computations.*

A few years ago, Charles Leedham-Green and I introduced a pruned version of p-group generation that computes certain Galois groups of interest to number theorists. This was adapted by Michael Bush and Harris Nover to perform massive computations of Galois groups of p-class towers. Refinements of this method with Jordan Ellenberg yield heuristics, some proven, for counting such extensions. Recently, with various collaborators, I have been extending these computations to obtain some non-abelian Cohen-Lenstra heuristics. (Received August 30, 2010)

1067-11-428 **Yinghui Wang*** (yinghui@mit.edu), 362 Memorial Dr, Cambridge, MA 02139, and **Steven J Miller** (Steven.J.Miller@williams.edu), 202 Bronfman Science Center, Williams College, Williamstown, MA 01267. *From Fibonacci Numbers to Central Limit Type Theorems.*

Every integer is uniquely a sum of non-adjacent Fibonacci numbers $\{F_n\}$, and the average number of summands for integers in $[F_n, F_{n+1})$ is $n/(\varphi^2+1)$ with φ the golden mean. We prove the following massive generalization: for integers $c_1, \dots, c_L \geq 0$ with $c_1, c_L > 0$ and recursive sequence $\{H_n\}_{n=1}^{\infty}$ with $H_{n+1} = c_1 H_n + c_2 H_{n-1} + \cdots + c_L H_{n+1-L}$ $(n \geq L)$, $H_1 = 1$ and $H_{n+1} = c_1 H_n + c_2 H_{n-1} + \cdots + c_n H_1 + 1$ $(1 \leq n < L)$, every integer can be written uniquely as $\sum a_i H_i$ under natural constraints on the a_i's, and the distribution of the number of summands converges to a Gaussian. Previous approaches were number theoretic, involving continued fractions, and were limited to results on existence and, in some cases, the mean. By recasting as a combinatorial problem and using generating functions and differentiating identities, we surmount these limitations.

Our method generalizes to many other problems. For example, every integer is uniquely a sum of the $\pm F_n$'s, such that every two terms of the same (opposite) sign differ in index by at least 4 (3). We prove the distribution of the numbers of positive and negative summands converges to a bivariate normal with correlation $-(21-2\varphi)/(29+2\varphi) \approx -0.551$. (Received September 02, 2010)

1067-11-430 **Boonrod Yuttanan*** (byuttan2@illinois.edu), 1409 W. Green Street, Urbana, IL 61801. *Certain Properties of the Ramanujan-Göllnitz-Gordon Continued Fraction.*

We derive new identities involving the Ramanujan-Göllnitz-Gordon continued fraction that are similar to those of the famous Rogers-Ramanujan continued fraction. We also show that the sign of the coefficients of power series associated with the Ramanujan-Göllnitz-Gordon continued fraction is periodic with period 8. (Received September 17, 2010)

1067-11-436 **Andrew V Sutherland*** (drew@math.mit.edu), Department of Mathematics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139. *Genus 1 point counting in quadratic space and essentially quartic time.*

The Schoof-Elkies-Atkin (SEA) algorithm is the method of choice for counting points on an elliptic curve modulo a prime p. Its main limitation is the size of the modular polynomials it requires. The largest of these uses on the order of $n^3 \log n$ bits of storage, where $n = \log p$, and their aggregate size is quartic in n.

I will describe a modified version of the SEA algorithm that requires only quadratic space, based on a method for directly computing instantiated modular polynomials via an explicit form of the Chinese remainder theorem. This algorithm is not only able to handle much larger problem sizes, its reduced space complexity also yields a better running time. These results have led to a new point counting record, modulo a prime p with more than 5000 decimal digits. Time permitting, I will discuss how the same techniques may be applied to some other problems in computational number theory. (Received September 03, 2010)

1067-11-442 **Jeffery E. Breeding*** (jbreeding@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019-0315. *The representation theory of GSp(4).*

Admissible non-supercuspidal representations of $\mathrm{GSp}(4, F)$, where F is a local field, have finite dimensional spaces of fixed vectors under the action of congruence subgroups. We can say precisely what these dimensions are for nearly all local fields and congruence subgroups by understanding the non-cuspidal representation theory of the finite group $\mathrm{GSp}(4, F_q)$. In this talk, we will examine the representation theory of this finite group and how it mirrors the theory for the group over a local field. (Received September 03, 2010)

1067-11-495 **Karl Dilcher**, **Rob Noble** and **Chris Smyth*** (c.smyth@ed.ac.uk). *Minimal polynomials of algebraic numbers with rational parameters.*

We show how to find all polynomials that are simultaneously the minimal polynomial of an algebraic number with rational real part, an algebraic number with rational imaginary part and an algebraic number with rational modulus. (Received September 07, 2010)

1067-11-499 **Chad Awtrey*** (cawtrey@elon.edu), Elon University, Campus Box 2320, Elon, NC 27244. *Galois groups of totally and tamely ramified sextic extensions of local fields.*

Let K be a finite extension of the p-adic numbers with $p > 3$, L/K a sextic extension, and G the Galois group of the splitting field of L. We prove that G must be either C_6 or D_6. Moreover, we show the determination of G depends only on the prime p and the residue degree of K. The techniques used are Krasner's mass formula, ramification considerations, and the Galois theory of cubic extensions. (Received September 07, 2010)

1067-11-524 **Karim Johannes Becher**, **David B Leep** and **Claus Schubert*** (claus.schubert@cortland.edu). *Semiorderings and stability index under field extensions.* Preliminary report.

We study the behavior of semiorderings and the stability index under field extensions. In particular, we show that the stability index may drop to any integer ≥ 1 under a quadratic extension. This does not happen in the case of a finite extension K/F where all orderings extend. However, even in this case, there may be fans in the ordering space $X(F)$ that do not extend to fans in $X(K)$. We investigate the relationship between the properties "K/F preserves orderings", "K/F preserves fans", and "K/F preserves semiorderings". (Received September 08, 2010)

1067-11-529 **Melanie Matchett Wood*** (mwood@math.stanford.edu), Stanford University, Dept of Mathematics, Building 380, Stanford, CA 94305. *Do the primes behave independently?*

In number fields, finite extensions of the rational numbers, rational primes such as 2,3,5 may no longer be prime–sometimes they factor in the extension. We ask the question of whether such factoring is independent for different primes. The question can be answered completely for extensions that have abelian Galois group, but the answer is more subtle than one originally expects. (Received September 08, 2010)

1067-11-597 **Atul Abhay Dixit*** (aadixit2@illinois.edu), 1009 W. Clark St., Apt. 101, Urbana, IL 61801. *Character analogues of Ramanujan type integrals involving the Riemann Ξ-function.*

A new class of integrals involving the product of Ξ-functions associated with Dirichlet characters is considered. These integrals give rise to transformation formulas of the type $F(\alpha, \chi) = F(\beta, \overline{\chi})$, where $\alpha\beta = 1$. New character analogues of transformation formulas of Ramanujan and Koshliakov are shown as particular examples. Character analogues of a theorem of Ramanujan, Hardy and Littlewood involving infinite series of Möbius function are also derived. (Received September 10, 2010)

1067-11-608 **Enrique Trevino*** (enrique.trevino@dartmouth.edu), 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755. *The Smoothed Pólya-Vinogradov Inequality and some Applications.* Preliminary report.

Let χ be a non-principal character to the modulus q. Let M and N be integers. The Pólya-Vinogradov inequality $\left|\sum_{a=M+1}^{N} \chi(a)\right| \leq cq^{1/2}\log q$, has been a very useful tool in number theory estimates. In a recent paper, Levin, Pomerance and Soundararajan use a modified version of this inequality for primitive characters which they call "Smoothed Pólya-Vinogradov". The smoothed version is convenient for numerical estimates. They use it to solve a conjecture of Brizolis. In this talk we'll talk about the smoothed inequality and give more applications. (Received September 10, 2010)

1067-11-614 **Caleb Emmons*** (emmons@pacificu.edu), Dept. of Mathematics and Computer Science, 2043 College Way, Forest Grove, OR 97116. *Continuation of the Riemann zeta function via derivations.* Preliminary report.

A derivation on a ring is an operator that acts like a derivative, namely it is linear and satisfies the product rule. In this talk I show how they may be used on the ring of Dirichlet series to achieve meromorphic continuations. In particular, I will present a recipe for an infinite family of representations of the Riemann zeta function as a quotient of Dirichlet series converging on $\Re(s) > 0$. (Received September 12, 2010)

1067-11-628 **Hung-ping Tsao** (tsaohp.tsao6@gmail.com), 1151 Highland Drive, Novato, CA 94949, and **Tingyao Xiong*** (txiong@radford.edu), Department of Mathematics and Statistics, Radford University, Radford, VA 24142. *Extensions of Eulerian Numbers to More General Triangular Arrays.*

We realize that the first-order Eulerian numbers are nothing but the coeffcients in a linear combination of binomial coefficents for the powered sum of the natural sequence. Doing the same for the Stirling numbers of both kinds, we obtain the second-order Eulerian numbers and alternate Eulerian numbers. By generalizing these numbers for arithmetically progressive sequences, we further recognize reursive formulas of such numbers for any sequence in a commutative ring. Based on various recursive formulas, we obtain a broader spectrum of triangular arrays of numbers for the underlying sequences such as Fibonacci numbers and q-sequence (powers of q). (Received September 22, 2010)

1067-11-635 **J. Brandt Kronholm*** (bkronholm@smcm.edu), St. Mary's College of Maryland, Department of Mathematics, 18952 E. Fisher Rd, Saint Mary's City, MD 20686-3001. *Ramanujan Congruence Properties of the Restricted Partition Function $p(n, m)$.*

Ramanujan-type congruences for the unrestricted partition function $p(n)$ are well known and have been studied in great detail. $p(n, m)$ is the restricted partition function that enumerates the number of partitions of n into exactly m parts.

The relationship between $p(n)$ and $p(n, m)$ is clear:

$$p(n) = p(n, 1) + p(n, 2) + \cdots + p(n, n-1) + p(n, n).$$

Until recently, the existence of Ramanujan-type congruences have been virtually unknown for this function. Let ℓ be any odd prime. In this presentation we will establish explicit Ramanujan-type congruences for $p(n, m)$ for $2 \leq m \leq \ell$ modulo any power of that prime ℓ^α. (Received September 12, 2010)

1067-11-665 **Benjamin Hutz*** (bhutz@gc.cuny.edu), CUNY Graduate Center, 365 Fifth Ave, Room 4208, New York, NY 10016, and **Michelle Manes**. *Rational self-maps on projective space with automorphisms.* Preliminary report.

The space of rational self-maps on projective space is acted on by elements of the projective linear group in a natural way through conjugation. The resulting equivalence classes forms a moduli space and one can study "interesting" families in this moduli space. One definition of interesting is maps which have a non-trivial automorphism group under the action of conjugation. In this talk we will examine the possible automorphism groups that can occur and the families that realize them. (Received September 13, 2010)

1067-11-678 **Alireza Salehi Golsefidy*** (asalehi@math.princeton.edu), Fine hall, Washington road, Princeton, NJ 08544, and **Peter Sarnak** and **Peter Varju**. *Affine sieve and expansion in perfect groups.*

In this talk, I report on the necessary and sufficient condition for a finitely generated subgroup of $\mathrm{SL}(n, \mathbb{Q})$ modulo square free integers give a family of expanders (Joint with Varju). Then I say how one can use such a result to get a fundamental affine sieve theorem (Joint with Sarnak). (Received September 13, 2010)

1067-11-690 **Emmanuel Kowalski*** (kowalski@math.ethz.ch), ETH Zurich - DMATH, Raemistrasse 101, 8092 Zurich, Switzerland. *Recent applications of expanders in number theory.*

The talk will give a survey of some recent applications of expander graphs in number theory, with an emphasis on general principles that seem to be widely applicable. In particular, the topics presented include large sieve inequalities in discrete groups with property (tau), and arithmetic properties of families of coverings of curves when the associated graphs are sufficiently expanding. (Partly joint works with F. Jouve and D. Zywina, and with J. Ellenberg and C. Hall) (Received September 13, 2010)

1067-11-708 **Ralph Greenberg**, **Karl Rubin** and **Alice Silverberg*** (asilverb@uci.edu). *Finding the rational points on a certain genus 12 curve.*

We study a certain genus 12 curve defined over the rational numbers. The determination of its rational points has applications to the sizes of images of 7-adic representations of elliptic curves over the rationals that have a rational subgroup of order 7. We use work of Poonen and Schaefer along with Stoll's version of the method of Chabauty to show that the set of rational points has size 6 or 12. The curve has 6 "obvious" rational points. It would be interesting to determine whether the 6 potential additional rational points really exist. (Received September 13, 2010)

1067-11-716 **Bruce C. Berndt**, **Sun Kim*** (kim@math.psu.edu) and **Alexandru Zaharescu**. *Weighted divisor sums and Bessel function series.*

On page 335 in his lost notebook, Ramanujan recorded without proofs two identities involving finite trigonometric sums and doubly infinite series of Bessel functions, which are intimately connected with the classical circle and divisor problems. In this talk, we discuss the proofs of them under two interpretations for the double series. Moreover, by extending the same ideas, we present three new identities, which involve analogous Bessel series. For example, one of our identities is for ${\sum_{nm\le x}}' \cos(2\pi n\theta)\sin(2\pi m\sigma)$. (Received September 14, 2010)

1067-11-726 **Jonathan Webster*** (jwebster@bates.edu), Bates College: Department of Mathematics, 3 Andrews Road, Lewiston, ME 04240. *Computations in Cubic Function Fields of Characteristic Three.*

We give an account of arbitrary cubic function fields when the underlying finite field has characteristic three. Defining a standard form for the underlying cubic curve allows us to easily calculate the discriminant, the genus, the splitting of any place, and an integral basis for the ring of integers. We state a composition and reduction algorithm for the ideal class group in the case that the infinite place is totally ramified. (Received September 14, 2010)

1067-11-734 **Jonathan Webster*** (jwebster@bates.edu), Bates College: Department of Mathematics, 3 Andrews Road, Lewiston, ME 04240, and **Pieter Rozenhart**. *The Simplest Cubic Function Fields.* Preliminary report.

We present the Shanks' simplest cubic fields in the function field setting, and also generalize the notion of a set exceptional units to function fields, namely the notion of k-exceptional units. We give a simple proof that the Shanks family is the only family of cyclic cubic function fields of unit rank 2 having k-exceptional fundamental units as roots. Removing the requirement that the extension be Galois, we show that there exist many different families of cubic function fields with k-exceptional units which stands in contrast to the number field setting. (Received September 14, 2010)

1067-11-749 **Elena Fuchs*** (efuchs@math.ias.edu), School of Mathematics, Institute for Advanced Study, Einstein Drive, Princeton, NJ 08542. *Counting primes in Apollonian circle packings.*

Integral Apollonian circle packings, in which all circles have integer curvature, are a prime example of the importance of expander graphs in number theory. We'll see how results of Bourgain, Gamburd, and Sarnak about expander graphs and the affine sieve apply to finding asymptotics for the number of circles of prime curvature, as well as pairs of tangent circles of prime curvature in ACP's. The relevant expander graph property, combined with an analog of the chinese remainder theorem in this example, give an experimentally supported heuristic for these counts. This is joint work with K. Sanden. (Received September 14, 2010)

1067-11-905 **Laura L Steil*** (laura.steil@uky.edu), Department of Mathematics, 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506, and **David Leep**. *Isometry Classes of Quadratic Forms over p-adic Rings.* Preliminary report.

Let f be a quadratic form defined over $\mathbb{Z}_p$, the ring of p-adic integers, and let $N_i(f)$ denote the number of solutions of $f \equiv 0 \mod p^i$. In this talk we seek to find a formula for $N_i(f)$, and thus define a sequence $\{N_i(f)\}_{i=1}^{\infty}$. Then we determine whether this sequence and the dimension of f are sufficient to determine the isometry class of f over $\mathbb{Z}_p$. (Received September 16, 2010)

1067-11-921 **Lenny Jones*** (lkjone@ship.edu), Department of Mathematics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257. *Appending Digits to Generate an Infinite Sequence of Composite Numbers I.*

Let $d \in \{0, 1, \dots, 9\}$, and let k be a positive integer. We generate an infinite sequence $\{s_n\}_{n=1}^{\infty}$ of positive integers by repeatedly appending the digit d on the right of k. For example, if $k = 35$ and $d = 1$, then the sequence $\{s_n\}_{n=1}^{\infty}$ is:

$$s_1 = 351, \quad s_2 = 3511, \quad s_3 = 35111, \quad s_4 = 351111, \dots.$$

For each value of d, we investigate when there exist infinitely many positive integers k such that every term of the sequence $\{s_n\}_{n=1}^{\infty}$ is composite. (Received September 16, 2010)

1067-11-923 **Lenny Jones** and **Dan White*** (dw9878@ship.edu), Department of Mathematics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257. *Appending Digits to Generate an Infinite Sequence of Composite Numbers II.* Preliminary report.

Let $D = [d_1, \dots, d_t]$, where $d_i \in \{0, 1, \dots, 9\}$, and let k be a positive integer. We generate an infinite sequence $\{s_n\}_{n=1}^{\infty}$ of positive integers by repeatedly appending, in order, one at a time, the digits from the list D to the integer k, in one of four ways: always on the left, always on the right, alternating and starting on the left, or alternating and starting on the right. For example, if $k = 35$ and $D = [1, 7, 9]$, then the sequence generated by appending the digits from D to k in an alternating manner, starting on the left, is:

$$s_1 = 135, \quad s_2 = 1357, \quad s_3 = 91357, \quad s_4 = 913571, \quad s_5 = 7913571, \ldots.$$

In each of these four situations, we investigate, for various lists D, when there exist infinitely many positive integers k, such that every term of the sequence $\{s_n\}_{n=1}^{\infty}$ is composite. (Received September 16, 2010)

1067-11-938 **John R. Greene*** (jgreene@d.umn.edu), Department of Mathematics and Statistics, University of Minnesota Duluth, Duluth, MN 55812. *Limiting structure for some central binomial evaluations.*

Series of the form

$$\sum_{n=0}^{\infty} \frac{(n!)^2(4x^2)^n}{(2n)!(2m+2n+1)}$$

and

$$\sum_{n=0}^{\infty} \frac{(n!)^2(-4x^2)^n}{(2n)!(2m+2n+1)}$$

are examined. In each case, there is an evaluation of the form

$$(p_m(x)f(x) - q_m(x))/x^{2m}$$

where $f(x)$ is a transcendental function and $p_m(x)$ and $q_m(x)$ are polynomials with rational coefficients. We prove that for $|x| < 1$,

$$\lim_{m\to\infty} \frac{q_m(x)}{p_m(x)} = f(x).$$

(Received September 16, 2010)

1067-11-946 **Robert P Boyer*** (rboyer@math.drexel.edu), 3141 Chestnut Street, Philadelphia, PA 19104, **William M. Y. Goh** (wmygoh@hotmail.com), Hefei, PA 230026, and **Daniel T Parry** (dtp29@drexel.edu), 3141 Chestnut Street, Philadelphia, PA 19104. *Asymptotics and Zeros for Partition Statistics Polynomials.* Preliminary report.

We continue to study the asymptotics of polynomial versions $\{F_m(x)\}$ of partition functions whose generating functions have the product form

$$1 + \sum_{m=1}^{\infty} F_m(x)q^m = \prod_{n=1}^{\infty} \frac{1}{(1-xq^n)^{\alpha_n}}$$

with emphasis on the limiting behavior of their zeros.

Previously Boyer and Goh studied the case: $\alpha_n = 1$. Then the coefficients of $F_m(x)$ are the partitions of m with exactly k parts. With a refinement of the circle method, they found that the asymptotics inside the unit disk surprisingly have three distinct regions and the zeros converge to the boundaries of these regions.

We begin the study of other families. Two important examples are (1) $\alpha_n = n$ that gives plane partitions indexed by their trace and (2) partitions whose parts lie in a residue class modulo N fixed. For the plane partitions, the polynomial zeros inside the unit disk converge $[r_0, 0]$ where r_0 is the solution of $f_1(x) = f_2(x)$, $x < 0$, and the curve $f_1(x) = f_2(x)$ with $\Im x \neq 0$. Here $f_k(x) = \Re[\sqrt[3]{\mathrm{Li}_3(x^k)}]/k$ where $\mathrm{Li}_3(x)$ is the trilogarithm. The curves for the zeros in family (2) are given in terms of the real part of the square root of dilogarithm and Lerch phi functions. (Received September 16, 2010)

1067-11-958 **Jodi A. Black*** (jablack@emory.edu), Dept. of Mathematics and Computer Science, Emory University, 400 Dowman Drive, Suite W401, Atlanta, GA 30322. *Zero Cycles on Principal Homogeneous Spaces over Fields of Virtual Cohomological Dimension at most 2.*

Let k be a field of virtual cohomological dimension ≤ 2 and characteristic 0. Let G be a connected reductive k-group such that a simply connected group associated to G is of classical type, type F_4 or type G_2. We show that a principal homogeneous space under G over k which admits a zero cycle of degree one has a k-rational point. (Received September 16, 2010)

1067-11-959 **Jodi A. Black*** (jablack@emory.edu), Dept. of Mathematics and Computer Science, Emory University, 400 Dowman Drive, Suite W401, Atlanta, GA 30322. *Zero Cycles on Principal Homogeneous Spaces under Semisimple Groups.*

Let k be a field of characteristic different from 2 and let G be a simply connected or adjoint, semisimple algebraic k-group without an absolutely simple factor of type E_8 and such that every absolutely simple factor of exceptional type is quasisplit. Let $S(G)$ be the set of homological torsion primes of G. We show that a principal homogenous space under G over k which admits a zero cycle of degree not divisible by the primes in $S(G)$ has a k-rational point. (Received September 16, 2010)

1067-11-1014 **David Petrie Moulton***, IDA–Center for Communications Research, 805 Bunn Dr, Princeton, NJ 08540. *Finding small sets whose subset sums include a given set.* Preliminary report.

At the 1997 West Coast Number Theory Conference at Asilomar, Gerry Myerson asked whether one could find n numbers whose subset sums include the $n+1$ powers of 2 up to 2^n. After Peter Montgomery found the set $\{1, -5, 7, 9\}$, representing $\{1, 2, 4, 8, 16\}$, I became interested in generalizations of the problem. I began searching for the smallest sets whose subset sums include some target set, like the first n powers of r or the first n factorials, and I proved some asymptotic results. Recently, after speeding up my computational code, I found a number of surprising representing sets that conflicted with my previous intuition. I will discuss basic results, some code optimizations, and a few interesting examples. (Received September 17, 2010)

1067-11-1029 **Mark Budden** and **Nicole Calkins*** (nc4639@stu.armstrong.edu), 25 Finch ln, Richmond Hill, GA 31324, and **William Nathan Hack**, **Joshua K Lambert** and **Kimberly Thompson**. *Enumeration of Triangles in Quartic Residue Graphs.*

Quartic residue graphs are graphs whose vertices are the elements of $\mathbb{Z}/p\mathbb{Z}$, where p is a prime congruent to 1 modulo 4, and the edges are formed when the difference between the vertices is a quartic residue. We wish to extend the results found in Maheswari and Lavaku's article on the relationship between the number of triangles in a quadratic residue graph and the number of consecutive pairs in the quadratic residues into a similar connection for quartic residues and their associated quartic residue graphs. (Received September 17, 2010)

1067-11-1060 **Qingquan Wu*** (qingqquan.wu@tamiu.edu), Dept of Engineering, Mathematics, and Physics, Texas A&M International University, 5201 University Boulevard, Laredo, TX 78041. *The Ramification Group Filtrations of Elementary Abelian Extensions and Beyond.* Preliminary report.

Let K be a discrete valuation field with a discrete valuation and associated place P. We investigate the ramification group filtration of an elementary abelian extension L/K at P. Due to the intimate interplay between the ramification group filtration and the different exponent in all of the sub-extensions of prime degree over K, we can treat number fields, function fields, and local fields simultaneously. The Hasse-Arf property is shown to be true and best possible.

Time permitting, we will also talk about how to generalize the results into other Galois extensions with non-abelian Galois groups. (Received September 17, 2010)

1067-11-1074 **Jeffrey A Manning*** (jmanning@caltech.edu), 1200 E CALIFORNIA BLVD MSC 658, Pasadena, CA 91126-0001. *EZADS Inputs which Produce Half-Factorial Block Monoids.*

We study the factorization properties of block monoids $\mathcal{B}(\mathbb{Z}/q\mathbb{Z}, S)$ resulting from the EZADS construction given by Chapman and Smith. This construction, which is inspired by a paper of Erdös and Zaks, takes a finite set of integers (called an EZADS input) and produces a weakly half-factorial block monoid with a simple atomic structure. We are primarily interested in determining which EZADS inputs will produce a half-factorial block monoid.

We first show that if an EZADS input produces a half-factorial block monoid, then so will any of its subsets. We then derive a bound which significantly simplifies the problem of determining whether a block monoid resulting from the EZADS construction is half-factorial. Using this bound, we reformulate the problem in terms of continuous quantities, then we apply these ideas to study three-element EZADS inputs. We describe a finite algorithm which, for fixed m, can be used to classify *all* EZADS inputs in the form $\{m, a, b\}$ which produce a half-factorial block monoid. (Received September 18, 2010)

1067-11-1094 **Krishanu Roy Sankar*** (sankark1991@gmail.com), 4 Saunders Street, Hastings on Hudson, NY 10706. *On Nathanson's problem in number theory and geometric group theory.*

Call $K \subset \mathbb{R}^n$ an $\mathcal{N}$-set if K is compact and $K + \mathbb{Z}^n = \mathbb{R}^n$. Nathanson asked which subsets $A \subset \mathbb{Z}^n$ can be written in the form $(K-K) \cap \mathbb{Z}^n$ for K an $\mathcal{N}$-set. It is known that A must generate $\mathbb{Z}^n$, and that this condition is sufficient in one dimension, but not much else is known other than that it is not sufficient in two dimensions. We partially address this question. First, we can define a notion of 'connectedness' between nonzero elements of

$A \subset \mathbb{Z}^n$: if the sum or difference of two nonzero elements of A is in A, we call them connected. We show that if A can be written in the desired form, then some connected component of A can be as well. We explore various generalizations of this theorem, the problem itself, and the methods used. Some conjectures and open questions are discussed. (Received September 18, 2010)

1067-11-1131 **Zhu Cao** and **Xinyun Zhu*** (zhu_x@utpb.edu), Odessa, TX 79762. *A proof of Ewell's Octuple Product Identity.* Preliminary report.

We give a simple proof of Ewell's octuple product identity in "On an octuple-product identity" by using a general theorem developed by the first author in "Integer matrix exact covering systems and product identities for theta functions". (Received September 19, 2010)

1067-11-1145 **Trueman MacHenry*** (machenry@mathstat.yorku.ca), Dept. of Math. and Statistics, York University, 4700 Keele St., Toronto, Canada M3J 1P3, Toronto, Ontario M3J 1P3, Canada, and **Geanina Tudose**. *Differential Operators and Weighted Isobaric Polynomials.*

We characterize those sequences of weighted isobaric polynomials which belong to the kernel of the linear operator

$$D_{1,1} - \sum_{j=1}^{k} t_j D_{2,j} - mD_2, m \in \mathbb{N};$$

and we characterize those linear operators of this form in terms of the coefficients a_j which have a non-zero kernel. The main result is that the sequence of Generalized Lucas Polynomials is a solution for $m = 1$ and the sequence of Generalized Fibonacci Polynomials is a solution when $m = 2$. (Received September 19, 2010)

1067-11-1171 **Ken Dutch*** (ken.dutch@eku.edu), Department of Mathematics and Statistics, Eastern Kentucky University, Richmond, KY 40475, and **Peter Johnson** (johnspd@auburn.edu), **Christopher Maier** (8maier@gmail.com) and **Jordan Paschke** (jpaschke@u.rochester.edu). *A Frobenius Problem for the Ring of Integers in a Number Field.*

The Frobenius coin problem seeks to find for any set of coins with mutually relatively prime integer denominations the maximal integer price which is not expressible as a non-negative integer linear combination of the coins. Equivalently the problem can be recast as finding the maximal positively-directed ray in the integers which is covered by non-negative integer linear combinations of the coin values. In the integer ring of a number field, we investigate an extension of the Frobenius problem where the "coins" are now algebraic integers residing the closed first quadrant, "non-negative integer linear combinations" are extended to include any algebraic integer coefficients which are themselves expressible as non-negative linear combinations of a selected first quadrant basis for the field extension, and "rays" are now translates of the integer portion of the smallest convex cone spanning all possible "non-negative integer linear combinations" of the "coins". We show that the set of maximal covered "rays" is non-empty, but finite, for number fields containing no irrational real number. We also provide explicit constructions for the maximal rays for several coin sets in the Gaussian integers. (Received September 19, 2010)

1067-11-1191 **Michael J Jacobson, Jr.*** (jacobs@cpsc.ucalgary.ca), Department of Computer Science, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada. *Class Group and Regulator Computation in Quadratic Fields.*

The ideal class group and regulator of a quadratic field are well-studied and widely-used invariants, applicable to such diverse areas as integer factorization, Diophantine equation solving, and public-key cryptography. In this talk, we discuss the state-of-the-art of algorithms for their computation, as well as possible future directions and obstacles with respect to improvements. (Received September 20, 2010)

1067-11-1255 **Eric Errthum*** (eerrthum@winona.edu), Winona State University, 322 Gildemeister Hall, Winona, MN 55987. *Minimal Polynomials of Singular Moduli.* Preliminary report.

We will demonstrate a technique to algebraically determine the minimal polynomials for singular moduli with small discriminants on the classical modular curve. We then extend this technique to computing the minimal polynomials for a significant number of singular moduli on small Shimura curves. With the minimal polynomials at hand, we examine the ABC ratios of these algebraic numbers and discuss the likelihood of finding "good" ratios. (Received September 21, 2010)

1067-11-1277 **Curtis N Cooper*** (cooper@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093. *The k-Zeckendorf Array.*

Let $k \geq 2$ be an integer. We define the k-generalized Fibonacci sequence, the k-Zeckendorf representation of a positive integer, and the k-Zeckendorf array. When $k = 2$ these definitions are the Fibonacci sequence, the Zeckendorf representation of a positive integer, and the Zeckendorf array defined by Kimberling. The 3-Zeckendorf array is

1	2	4	7	13	24	44	81	149	274	504	$\cdots$
3	6	11	20	37	68	125	230	423	778	1431	
5	9	17	31	57	105	193	355	653	1201	2209	
8	15	28	51	94	173	318	585	1076	1979	3640	
10	19	35	64	118	217	399	734	1350	2483	4567	
12	22	41	75	138	254	467	859	1580	2906	5345	
14	26	48	88	162	298	548	1008	1854	3410	6272	
16	30	55	101	186	342	629	1157	2128	3914	7199	
18	33	61	112	206	379	697	1282	2358	4337	7977	
$\vdots$											

We prove that each of these k-Zeckendorf arrays is an interspersion. (Received September 20, 2010)

1067-11-1282 **David B. Leep*** (leep@email.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506-0027. *Levels and Pythagoras numbers of commutative rings.* Preliminary report.

The level, $s(R)$, of a commutative ring R is the smallest integer n such that $-1 = a_1^2 + \cdots + a_n^2$ with each $a_i \in R$. If $s(R)$ is finite, we give rather precise estimates in terms of $s(R)$ for the sublevel and the Pythagoras number for the ring R, the polynomial ring $R[t]$, and the ring of formal power series $R[[t]]$. Some of the estimates improve results of M. Peters. Other results and open questions related to work of Dai-Lam will be presented. (Received September 20, 2010)

1067-11-1372 **Andrew G. Earnest*** (aearnest@math.siu.edu), Department of Mathematics, Southern Illinois University Carbondale, Carbondale, IL 62901. *Multiplicative properties of integral binary quadratic forms and orders of elements in the form class group.*

It follows from the classical Gaussian theory of composition that the set of integers represented by an integral binary quadratic form is closed under three-fold products. The integral binary quadratic forms for which the represented value set is multiplicatively closed were studied by V. Arnold, who referred to them as perfect forms. In this talk we will discuss more generally the integral binary quadratic forms for which the represented value set is closed under k-fold products, for any even positive integer k. This property will be seen to distinguish the elements of odd order in the form class group of a fixed discriminant. Moreover, this closure under k-fold products can always be expressed by a k-linear mapping. In the case $k = 2$, this property is seen to be related to a particular parametrization of the coefficients of the form which arises from a classical correspondence between binary cubic forms and related binary quadratic forms. (Received September 20, 2010)

1067-11-1398 **Keenan Monks*** (keenaneek@gmail.com). *On Supersingular Elliptic Curves and Hypergeometric Functions.*

The Legendre Family of elliptic curves has the classic and remarkable property that both its periods and its supersingular locus have descriptions in terms of the ${}_2F_1\left(\begin{matrix}\frac{1}{2} & \frac{1}{2} \\ & 1\end{matrix}\middle|\, z\right)$ hypergeometric function. El-Guindy and Ono proved an analogous result for a different infinite family of curves with respect to the ${}_2F_1\left(\begin{matrix}\frac{1}{4} & \frac{3}{4} \\ & 1\end{matrix}\middle|\, z\right)$ hypergeometric function. Both of these hypergeometric functions can also be written as elliptic integrals of the first kind. Two other hypergeometric functions that can be written as elliptic integrals are ${}_2F_1\left(\begin{matrix}\frac{1}{3} & \frac{2}{3} \\ & 1\end{matrix}\middle|\, z\right)$ and ${}_2F_1\left(\begin{matrix}\frac{1}{12} & \frac{5}{12} \\ & 1\end{matrix}\middle|\, z\right)$. We prove that the supersingular λ-invariant loci of two specific families of elliptic curves are given by these functions. (Received September 20, 2010)

1067-11-1431 **Allison L. Lewis*** (lewisa11@up.edu), **Steven J. Miller** (Steven.Miller@williams.edu) and **Victoria Cuff** (vcuff@clemson.edu). *Theory and Applications of Benford's Law of Leading Digits.* Preliminary report.

Benford's Law of Leading Digits contributes to the analysis of a variety of real-life data sets, providing us with a method to detect abnormalities in data resulting from rounding errors, data collection methods, or even nefarious activities such as fraud. We perform an in-depth analysis on several diverse, natural data sets, including data from Climategate, results from the 2009 Iranian elections, and streamflow statistics, analyzing the conformity of each data set to Benford's Law and other digit distributions. We develop a set of general techniques that can be applied to large data sets in a Benford analysis, and discuss the issues encountered due to a lack of significant digits, the sensitivity of the chi-square analysis, and simply non-Benford behavior. Exploring the theoretical implications of Benford's Law, we expand upon previous results from Miller and Nigrini (regarding the Exponential distribution) and generalize to the Weibull distribution, investigating how the variation of its parameters affects its conformity to the expected leading digit probabilities. The major goal of this study is to determine which data sets should be governed by Benford's Law, based on factors such as size and the presence of data entries spanning multiple orders of magnitude. (Received September 21, 2010)

1067-11-1462 **Paul Jenkins** and **Jeremy Rouse*** (rouseja@wfu.edu), Department of Mathematics, Wake Forest University, P.O. Box 7388, Winston-Salem, NC 27109. *Modular forms with non-negative Fourier coefficients and extremal lattices.*

If

$$f(z) = \sum_{n=1}^{\infty} a(n) q^n$$

is a cusp form of weight k for the full modular group it is known that there is a constant C_f so that

$$|a(n)| \le C_f d(n) n^{\frac{k-1}{2}}.$$

Such a form $f(z)$ is determined by its first $\ell = \lceil \frac{k}{12} \rceil$ coefficients, and our first main result is a bound on C_f in terms of $a(1), a(2), \ldots, a(\ell)$.

We apply this result to the study of extremal lattices. The theta function of such a lattice will be the unique (non-cuspidal) modular form of weight k with

$$f(z) = 1 + O(q^{\ell+1})$$

and will have non-negative coefficients. We show that the form $f(z)$ has non-negative coefficients when $k = 81632$, but that some coefficients are negative when $k = 81644$. (Received September 21, 2010)

1067-11-1528 **Mark Budden**, **Nicole Calkins**, **William Nathan Hack**, **Joshua K Lambert** and **Kimberly Thompson*** (sue144@hotmail.com), 704 North Main Street, Hinesville, GA 31313. *Enumeration of Triangles in Rational Residue Graphs.*

Bommireddy Maheswari and Madhavi Lavaku were the first to introduce quadratic residue graphs. Their studies gave us a method of enumerating the triangles in such graphs. We can extend these results further to a rather new topic in graph theory, rational residue graphs. Given $p \equiv 1 \bmod 2^t$, rational residues graphs, denoted by $G_{2^t}(p)$, can be defined as graphs whose vertices are the elements in the set $V(G_{2^t}(p)) = \mathbb{Z}/p\mathbb{Z}$ and whose edges belong to $E(G_{2^t}(p)) = \{xy | x - y \text{ or } y - x \in (\mathbb{Z}/p\mathbb{Z})^{\times 2^t}\}$. We will discuss how the number of pairs of consecutive rational residues determines the number of triangles in rational residue graphs. (Received September 21, 2010)

1067-11-1529 **David Grant** and **Su-ion Ih*** (ih@math.colorado.edu), Campus Box 395, Department of Mathematics, University of Colorado at Boulder, Boulder, CO 80309-0395. *A property of division points.*

I will describe a Diophantine or number-theoretic property of division points on curves and discuss its various related arithmetic issues. This is joint work with David Grant. (Received September 21, 2010)

1067-11-1564 **Rainer Dietmann*** (Rainer.Dietmann@rhul.ac.uk), Royal Holloway, University of London, Department of Mathematics, Egham, TW20 0EX, England. *Weyl's inequality and systems of quadratic forms.*

Building on earlier work of Birch on forms in many variables, Schmidt has shown that any system of r rational quadratic forms has a non-trivial rational zero, providing that each form in the rational pencil has rank exceeding $2r^2 + 3r$, and providing that there are non-singular real and p-adic zeros. One of the main ingredients in his work is a form of Weyl's inequality from Birch's paper, which we can use more efficiently for systems of forms. This way we are able to replace the bound $2r^2 + 3r$ to $2r^2 + 2r$. In particular, for $r = 1$ one recovers Minkowski's classical result on isotropy of indefinite rational quadratic forms in at least five variables. (Received September 21, 2010)

1067-11-1603 **Heon Kim*** (hkim@suno.edu), 47 Echezeaux Dr., Kenner, LA 70065. *Infinite class of new sign ambiguities.*

In this paper, we study the multiplicative relations of Gauss sums, investigate a new type of multiplicative relations, and decide explicitly ambiguous signs. (Received September 21, 2010)

1067-11-1621 **Adriana Salerno*** (asalerno@bates.edu), 3 Andrews Rd, Lewiston, ME 04240. *The Dwork Family and Hypergeometric Functions.*

In his work studying the Zeta functions of families of hypersurfaces, Dwork came upon a one-parameter family of hypersurfaces in $\mathbb{P}^{n-1}$ (now known as *the* Dwork family), defined by:

$$X_\lambda : x_1^n + \cdots + x_n^n - n\lambda x_1 \cdots x_n = 0.$$

These examples were not only useful to Dwork in his study of his deformation theory for computing Zeta functions of families, but they have also proven to be extremely useful to physicists working in mirror symmetry. A startling result is that these families are very closely linked to hypergeometric functions. This phenomenon was carefully studied by Dwork in the cases where $n = 3, 4$ and for $n = 5$ by Candelas, de la Ossa, and Rodríguez-Villegas. Dwork, Candelas, et.al. observed that, for these families, the differential equation associated to the Gauss-Manin connection is in fact hypergeometric. We have developed a computer algorithm, implemented in Pari-GP, which can check this result for larger values of n by computing the Gauss-Manin connection and the parameters of the hypergeometric differential equation. (Received September 21, 2010)

1067-11-1694 **Matthew Musson*** (mmusson@math.ucalgary.ca), 2500 University Drive NW, Department of Mathematics and Statistics, Math Building Rm. 476, Calgary, Alberta T2N 1N4, Canada. *Another look at the GHS Attack on the Elliptic Curve Discrete Logarithm Problem.*

We take a second look at the GHS Attack on the ECDLP. This time we relax the conditions of Hess' theorem in its analysis and find more curves appearing in the Weil Restriction. Relaxing the conditions of Hess' theorem benefits us especially in the case where curves are defined over $\mathbb{F}_{2^n}$ where $n = 2p, 3p$ or $4p$ for some prime p such that $2^n > 2^{160}$. In particular, we classify all curves appearing via the GHS attack over $\mathbb{F}_{q^2}$ and determine the full security impact on the fields $\mathbb{F}_{q^3}$ and $\mathbb{F}_{q^4}$. Our analysis suggests that the fields $\mathbb{F}_{q^4}$ are bad for elliptic curve cryptography - the first such fields; and should never be used in cryptographic protocols. We then turn our attention to fields of the form $\mathbb{F}_{q^5}$ and discuss the security impact of our findings, focusing on the curves found in the Oakley Key Determination Protocol. Lastly, we discuss ongoing research and open problems concerning this attack. (Received September 21, 2010)

1067-11-1718 **Stephen Edward Winburn*** (stephenedwardwinburn@gmail.com), 289 Kennington Dr., Athens, GA 30606. *Lipschitz Bounds for Rational Functions De fined over the Berkovick Projective Line over an Algebraically Closed and Complete Non-Archimedean Field.* Preliminary report.

We look at the Lipschitz bound of a rational function on $\mathbb{P}^1_{\mathrm{Berk,K}}$, where K is algebraically closed, complete non-Archimedean field. While exploring this topic we consider the consequences of our choice of metric and suggest alternative metrics.We also provide quantitative values for the Lipschitz bound for fractional linear transformations and polynomials of degree less than or equal to three. (Received September 21, 2010)

1067-11-1735 **Barry R Smith*** (barsmith@lvc.edu), Department of Mathematical Sciences, Lebanon Valley College, 101 N. College Ave., Annville, PA 17003. *Some congruences connecting values at $s = 0$ of partial zeta functions with units.* Preliminary report.

We present new congruences between (1): special values at $s = 0$ of partial zeta functions for certain abelian extensions $K/\mathbb{Q}$ and (2): expressions created from units in K. These generalize congruences invented by Coates and Sinnott during their construction of p-adic zeta functions for real quadratic fields as well as congruences of Kiselev, Ankeney-Artin-Chowla and Feng. (Received September 21, 2010)

1067-11-1779 **Benjamin L Weiss*** (blweiss@umich.edu), Department of Mathematics, 530 Church St., Ann Arbor, MI 48109. *The classification of curves $G(X) = H(Y)$ with infinitely many rational points.* Preliminary report.

The goal of this talk is to classify all pairs of polynomials (G, H) over a number field K such that $G(X) = H(Y)$ has infinitely many solutions in K^2. By an application of Faltings' Theorem, this is equivalent to classifying all such curves with an absolutely irreducible factor of genus 0 or 1. This talk will discuss the main techniques used towards achieving this goal: the Riemann-Hurwitz equation and combinatorics of possible ramification, Riemann's existence theorem to count the number of polynomials with a given ramification structure, and time permitting applications of a group theoretic result of Fried which extends the results from irreducible curves to reducible curves. This talk is an outline of the author's thesis. (Received September 22, 2010)

1067-11-1836 **Tim Huber*** (hubertj@utpa.edu), University of Texas-Pan American, Department of Mathematics, Edinburg, TX 78539. *Differential equations for cubic theta functions.*

We show that the cubic theta functions satisfy two distinct coupled systems of nonlinear differential equations. The resulting relations are analogous to Ramanujan's differential equations for Eisenstein series on the full modular group. Both systems are deduced by elementary means from trigonometric series identities arising in Ramanujan's original paper on Eisenstein series. We use the differential equations to give a short proof of a famous cubic theta function identity derived by J. and P. Borwein. (Received September 22, 2010)

1067-11-1847 **Marcus D. Ashford** and **Katrina K. A. Cunningham*** (katrina_cunningham@subr.edu), Department of Mathematics, 156 Elton C. Harrison St, Baton Rouge, LA 70813. *In Search of Pythagorean Triples.*

Given an integer $x > 2$, we propose a formula that allows one to find integers $y > 0$ and $z > 0$ in terms of x and a divisor either of x^2 or of $\frac{x^2}{4}$ so that (x, y, z) is a primitive Pythagorean triple. Moreover, for each positive integer $x > 2$, we show how to find a Pythagorean triple having x as one of its elements. (Received September 22, 2010)

1067-11-1872 **Chang Mou Lim*** (changmou.lim@yale.edu), P.O. Box 205578, New Haven, CT 06520-5578, and **Nicholas George Triantafillou** (ngtriant@umich.edu). *Random Additive 3-Bases & Sum-free Sets.* Preliminary report.

A set $A \subset \mathbb{Z}$ is an additive 3-basis for $B \subset \mathbb{Z}$ if given any $j \in B$, $j = x + y + z$, where $x, y, z \in A$. We create a random set A by choosing each integer in $[0, n]$ independently with identical probability p, and consider the threshold values of p for which A forms an additive 3-basis for $[n/2, 3n/2]$ as $n \to \infty$. This is found by approximating the distribution of the expected number of missing integers in the random sumset to a Poisson distribution, which is valid under appropriate values of p. The Stein-Chen method and Jansen's inequality are used critically in justifying our approximation. As a comparison, we also study threshold values of p for which random sumsets are sum-free. (Received September 22, 2010)

1067-11-1883 **Thomas J Wright*** (thomas.j.wright@lawrence.edu), Lawrence University, Mathematics Department, 711 E. Boldt Way - SPC 24, Appleton, WI 54911. *The Connection Between Germain Primes and Twin Primes.*

For many classes of pairs of primes (including twin primes, cousin primes, Sophie Germain primes, and other related prime pairs), it has been conjectured that the asymptotic density of these pairs is about $\frac{x}{\log^2 x}$. In this talk, we show that if the Sophie Germain primes are of this conjectured density and satisfy an additional assumption about well-distributedness in congruence classes then there are infinitely many twin primes. The result depends upon the use of adelic methods to restate an error term as a Schwartz function, thereby allowing for the use of Fourier analytic techniques. This is joint work with Ben Weiss. (Received September 22, 2010)

1067-11-1907 **Thomas Garrity***, Department of Mathematics and Statistics, Williams, Williamstown, MA 01267. *Generalizing Stern's Diatomic Sequences via Multi-dimensional Continued Fractions.* Preliminary report.

Continued fractions are linked to Stern's diatomic sequence $0, 1, 1, 2, 1, 3, 2, 3, 1, 4, \ldots$ (given by the recursion relation $a_{2n} = a_n$ and $a_{2n+1} = a_n + a_{n+1}$, where $a_0 = 0$ and $a_1 = 1$). Using a particular multi-dimensional continued fraction algorithm (the Farey algorithm), we will generalize the diatomic sequence to a collection of numbers that quite naturally should be called the tri-atomic sequence (or a two-dimensional Pascal with memory sequence). As continued fractions and the diatomic sequence can be thought of as coming from systematic subdivisions of the unit interval, this new tri-atomic sequence will arise by a systematic subdivision of a triangle. We will discuss some of the algebraic properties for the tri-atomic sequence. (Received September 22, 2010)

1067-11-1939 **Eric J Landquist*** (elandqui@kutztown.edu), Kutztown University, Department of Mathematics, Kutztown, PA 19530, and **Felix Fontein** and **Renate Scheidler**. *Class Number and Regulator Computation in Purely Cubic Function Fields of Unit Rank Two.*

This talk will describe and give computational results of a general procedure to compute the divisor class number and regulator of purely cubic function fields of unit rank 2. Our implementation is an improvement to Pollard's Kangaroo method in infrastructures, using distribution results of class numbers, as well as information on the congruence class of the divisor class number, and an adaptation that efficiently navigates these torus-shaped infrastructures. Moreover, this is the first time that an efficient "square-root" algorithm has been applied to the infrastructure of a global field of unit rank 2. With the exception of function fields defined by curves which are equivalent to purely cubic nonsingular curves, our examples are the largest known divisor class numbers and regulators ever computed for function fields of genera 4 through 7. (Received September 22, 2010)

1067-11-1946 **Trevor E McGuire*** (TMcGui1@lsu.edu), 303 Lockett Hall, LSU, Baton Rouge, LA 70803.
On Periodicity of some Fibonacci-like Sequences.

In recent years, random Fibonacci sequences have been studied in great detail, especially since Viswanath's 2000 result that they grow exponentially. Stemming from this research, it has been shown that one can modify the generating algorithm of the Fibonacci sequence in a natural way to generate periodic sequences. Namely, instead of adding the previous two terms together to get the next term, one subtracts, instead of adds, according to a given pattern called a motif. In this research, we examine the standard case of adding or subtracting two terms, and then generalize most results to the so-called n-nacci sequence. We will see the conditions under which a motif gives rise to a periodic sequence, and also some interesting properties of the lengths of the periods and their relation to prime numbers. (Received September 22, 2010)

1067-11-1987 **Alan Koch*** (akoch@agnesscott.edu), 141 E. College Ave., Decatur, GA 30030. *A connection between Hopf orders and Laurent series.* Preliminary report.

Let R be a complete discrete valuation ring of mixed characteristic $(0,p)$. Let K be its field of fractions and k its residue field. Suppose H is an R-Hopf order in KC_{p^n}, where C_{p^n} is a cyclic group of order p^n. We show that H corresponds to a sequence $\{f_1, f_2, \ldots, f_n\} \subset W_n((u))$, where $W_n((u))$ is the ring of Laurent series with coefficients in the truncated Witt vector ring $W_n(k)$. Conversely, given a sequence $\{f_1, f_2, \ldots, f_n\} \subset W_n((u))$ satisfying certain properties one can find an R-Hopf order in KC_{p^n}. Using Breuil-Kisin modules we establish this correspondence and give examples for small n. (Received September 22, 2010)

1067-11-2000 **F. G. Garvan*** (fgarvan@ufl.edu), Department of Mathematics, University of Florida, PO Box 118105, Gainesville, FL 32611-8105. *Higher order spt-functions.*

Andrews' spt-function can be written as the difference between the second symmetrized crank and rank moment functions. Using the machinery of Bailey pairs a combinatorial interpretation is given for the difference between higher order symmetrized crank and rank moment functions. This implies an inequality between crank and rank moments that was only known previously for sufficiently large n. This combinatorial interpretation is in terms of a weighted sum of partitions. A number of congruences for higher order spt-functions are derived. (Received September 22, 2010)

1067-11-2028 **Randy J Heaton*** (randy.heaton@gmail.com), 1816 Meriadoc, Tallahassee, FL 32303.
Congruences Between Spaces of Cuspidal Modular Forms.

A prime p is said to be a congruence prime linking two spaces of cuspidal modular forms X and Y if there exist two cusp forms, $f \in X$ and $g \in Y$, such that the Fourier coefficients of f and g are all congruent modulo p. We describe research to date on the problem and discuss a novel approach. (Received September 22, 2010)

1067-11-2080 **Michael A. Bennett*** (bennett@math.ubc.ca), 1984 Mathematics Road, Department of Mathematics, University of British Columbia, Vancouver, B.C. V6T 1Z2, Canada. *Effective solution of Norm-form equations.* Preliminary report.

Effective solution of norm-form equations has traditionally been based upon reduction to 3-term S-unit equations and subsequent application of lower bounds for linear forms in p-adic and complex logarithms. These reductions require the corresponding number fields to have quite special properties. We will consider an alternative approach, in itself rather specialized, that enables us in some circumstances to solve 3 or 4 variable S-unit equations where older methods fail. (Received September 22, 2010)

1067-11-2091 **Oscar G. Villareal*** (ovillare@gmail.com), 801 N Glassell St, Orange, CA 92867. *The Geyer-Jarden Conjecture in positive characteristic and the degree of torsion points.*

Let k be a finitely generated field, k_s a separable closure, and $G_k = \mathrm{Gal}(k_s/k)$ the absolute Galois group. For an e-tuple $\sigma = (\sigma_1, \ldots, \sigma_e) \in G_k^e$, let $k(\sigma)$ be the field fixed by $\sigma_1, \ldots, \sigma_e$. Let A be an abelian variety over k. We give a criterion for finiteness of the torsion group $A_{tors}(k(\sigma))$ and we show that this condition is satisfied when A admits analytic uniformization at some place of k. (Received September 22, 2010)

1067-11-2101 **Paul Pollack*** (pppollac@illinois.edu), 1409 W. Green St., Department of Mathematics, MC-382, University of Illinois, Urbana, IL 61801. *Sociable numbers, or* How I messed with perfection and lived to write papers about it.

Let $s(n) := \sum_{d|n,d<n} d$ denote the sum of the proper divisors of the natural number n. We call n *perfect* if $s(n) = n$. The study of such numbers goes back thousands of years, but many of the most natural questions remain unanswered. Similar comments apply to the study of *amicable pairs*, which are pairs of natural numbers n and m for which $s(n) = m$ while $s(m) = n$. (In this case, both n and m are called *amicable numbers*.) I will describe recent results concerning perfect numbers, amicable numbers, and their higher-order generalizations, so-called *sociable numbers*. (Received September 22, 2010)

1067-11-2110 **Chadwick Gugg*** (cgugg@canes.gsw.edu), Georgia Southwestern State University, Department of Mathematics, 800 GSW State University Drive, Americus, GA 31709. *Modular identities involving powers of the Rogers-Ramanujan functions.*

In his Notebooks, Ramanujan recorded 40 elegant identities for the Rogers-Ramanujan functions. Of these, precisely one involves powers of the Rogers-Ramanujan functions. Ramanujan added the enigmatic note that "Each of these formulae is the simplest of a large class." This suggests that there are further relations involving powers of the Rogers-Ramanujan functions. In this talk, we provide examples of identities involving powers of the Rogers-Ramanujan functions. Connections are made to continued fractions, partitions, and analogues of the Rogers-Ramanujan functions. (Received September 22, 2010)

1067-11-2267 **Edray Herber Goins*** (egoins@math.purdue.edu), Mathematical Sciences Building, 150 North University Street, West Lafayette, IN 47907. *Galois Representations and L-Series: A Tour Through Mathematics.*

Modern number theory has translated questions of rational numbers satisfying various conditions into questions of points on group schemes. For example, the infinitude of primes in arithmetic progressions may be shown using representations associated to cyclic groups; and even Fermat's Last Theorem may be shown using representations associated to elliptic curves. Surprisingly, many branches of math come into play: the topology of Galois groups, the combinatorics of counting points over finite fields, the linear algebra of Tate modules, and the analysis of the convergence of L-series. In this talk we give a tour of the mathematics used to answer questions from number theory and discuss some open problems from the Langlands Program. (Received September 22, 2010)

1067-11-2272 **M.Tip E Phaovibul*** (mtphaovibul@yahoo.com), M.Tip Phaovibul, Department of Mathematics, 1409 W Green st, Urbana, IL 61801. *The distribution of the number of Farey fraction in residue classes.* Preliminary report.

Consider a sequence $\{\Phi(n)\}_n$ modulo m where $\Phi(n)$ is the number of Farey fraction level n. By extensive computation, we observes that if m is odd number then the sequence is seem to be equally distributed in all residue classes, moreover if m is even then the sequence is equally distributed in all odd residue classes. However, we only be able to show that for every residue classes modulo 3, we have a positive proportion and similarly for every odd residue classes modulo 4. We will discuss why our method succeed for this two modules, and can't be apply to other residue classes. (Received September 22, 2010)

1067-11-2299 **Chester J Weatherby*** (weatherby@math.udel.edu), Department of Mathematical Sciences, University of Delaware, Newark, DE 19713-2553. *On the transcendence of Fourier and other infinite series.*

We investigate the transcendental nature of the sums

$$\sum_{n\in\mathbb{Z}} \frac{f(n)A(n)}{B(n)} \quad \text{and} \quad \sum_{n\in\mathbb{Z}} \frac{A(n)}{B(n)}$$

where $A(x), B(x)$ are polynomials with algebraic coefficients with $\deg A < \deg B$, f is an algebraic valued periodic function, and the sum is over integers n which are not zeros of $B(x)$. By relating these sums to the Fourier series of certain functions we are able to obtain transcendence results. In certain cases we relate these sums to a theorem of Nesterenko regarding the algebraic independence of π and $e^{\pi\sqrt{D}}$ for positive integer D. (Received September 22, 2010)

1067-11-2326 **Robert Erra*** (erra@esiea.fr), ESIEA, 75005 PARIS, France. *A Bezoutian algorithm for Egyptian Fractions.* Preliminary report.

We present an Egyptian Fraction algorithm, *i.e.* an algorithm that computes, for a fraction p/q, integers $x_1, \dots x_k$ such that:

$$\frac{p}{q} = \frac{1}{x_1} + \frac{1}{x_2} + \dots \frac{1}{x_k}$$

The algorithm relies on the well known property (called Bezout identity in France): integers q and q are coprime if and only if it exists two integers u and v such that $p\,u + q\,v = 1$, and so, we propose to call it the *Bezoutian algorithm.*

This algorithm is simple and fast, it has some interesting properties:

- it computes at most p numbers so $k \leq p$ (as the Bleicher algorithm);
- $x_1 < q^2$;
- $x_1 > x_2 \dots > x_k$.
- for fractions $4/q$ if $q \neq 1 \mod 4$ then $k <= 3$.

If we allow the integers x_i to be negative, the algorithms helps to prove some known results about the Schinzel conjecture: for $a = 2, 3, 4, 5, 6, 7, 8$ then the equation

$$\frac{a}{q} = \frac{1}{x_1} \pm \frac{1}{x_2} \pm \frac{1}{x_3}$$

is always solvable for $q > a$.

Eventually, we present an Odd variant that computes, for a fraction p/q with q odd, odd denominators. The algorithm seems to compute a finite developement but we have no proof. (Received September 22, 2010)

1067-11-2334 **Zhu Cao***, Hume Hall 305, University, MS 38677. *On Somos' dissection identities.*

We give proofs of a list of M. Somos' dissection identities. An eta function identity presented by B. C. Berndt and W. B. Hart, a theorem by H. -C. Chan on the congruence property of $a(n)$ with generating function $(q;q)_\infty^{-1}(q^2;q^2)_\infty^{-1}$, and a theorem by G. E. Andrews, A. Schilling and S. O. Warnaar are showed to be related to dissection identities. Several new corollaries are also presented as applications. (Received September 22, 2010)

1067-11-2361 **Jorge Dioses*** (jdioses@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078-1058. *Relations between class numbers of binary cubic forms.*

In 1972, T. Shintani defined four Dirichlet series whose coefficients are class numbers of integral binary cubic forms, two of them for forms with positive discriminant and the other two for forms with negative discriminant. In 1998, J. Nakagawa proved a theorem, originally conjectured by Y. Ohno in 1997, which states that two of these series are essentially the same as the remaining two up to simple constant factors. In this presentation, we generalize these ideas and introduce new series whose coefficients are class numbers of binary cubic forms over the ring of integers in an imaginary quadratic field. We prove that any of these series is also equal to its corresponding dual series up to a constant factor. (Received September 22, 2010)

1067-11-2396 **Elizabeth McCaslin*** (eam013@mcdaniel.edu), 13579 Deer Brook Court, Mount Airy, MD 21771, and **Fenghao Wang**. *Improving Abundancy Bounds.*

We will examine the percentage of integers n such that $\frac{\sigma(n)}{n}$ is at least x, where $\sigma(n)$ is the sum of all positive divisors of n. It is known that the bounds for the solutions to $\frac{\sigma(n)}{n} \geq 2$ are 0.2474 and 0.2480; however, the previous best known bounds for some x are much wider. We explore methods for improving these bounds. (Received September 23, 2010)

1067-11-2421 **Douglas C Bowman*** (bowman@math.niu.edu), Professor Douglas Bowman, Northern Illinois University, Mathematical Sciences, Watson Hall 320, DeKalb, IL 60115. *Harmonic Continued Fractions.* Preliminary report.

Harmonic continued fractions are a new method for the expansion of real numbers. We describe the algorithm and its basic properties. It is also shown that when the algorithm is applied to the number π, the resulting digits follow a simple pattern. (Received September 23, 2010)

12 ► Field theory and polynomials

1067-12-196 **Kenneth B Ascher*** (kennyascher@gmail.com), 3444 Turf Road, Oceanside, NY 11572.
Random Trinomials and Lower Binomials. Preliminary report.

There is no general formula, using rational functions and radicals, for the roots of polynomials of degree 5 or more. We show how to compute the number of real, non-zero roots of trinomials (of arbitrary degree) using a simple logarithmic inequality. Using the log-uniform distribution for the coefficients, we then prove that the number of real roots is 3/2 on average. Finally, we show how an "Archimedian" Newton Polygon gives an algorithm to efficiently approximate the roots of f. (Received July 31, 2010)

1067-12-476 **Mélanie Raczek***, Département de Mathématiques, chemin du cyclotron 2, 1348 Louvain-la-Neuve, Belgium. *The 3-Pfister number of quadratic forms.*

Let F be a field of characteristic different from 2 containing a square root of -1. The 3-Pfister number of a quadratic form q in the third power of the fundamental ideal of F, is the least number of terms needed to write q as a sum of 3-fold Pfister forms. We use a combinatorial analogue of the Witt ring of F to prove that, if F is a 2-henselian valued field with at most two square classes in the residue field, then the 3-Pfister number of a d-dimensional quadratic form is less than or equal to $(d^2)/2$. (Received September 06, 2010)

1067-12-757 **Bill Jacob*** (jacob@math.ucsb.edu), Department of Mathematics, Santa Barbara, CA 93106, and **Roberto Aravire** (raravire@unap.cl), Casilla 121, Iquique, Chile. *The Graded Witt Group Kernel of Biquadratic Extensions in Characteristic Two.* Preliminary report.

This paper shows that the kernel on the graded Witt group for a separable biquadratic extension E/F is the expected group. To obtain the result ideas of Positselki are combined with results of Izboldin to obtain an exact sequence $\nu_F(n,1) \oplus \nu_F(n,1) \to H_2^{n+1}F \to H_2^{n+1}E$. This generalizes the result of Baeza in the ungraded case $\ker(W_q(F) \to W_q(L)) = I_F \cdot [1,a] + I_F \cdot [1,b]$. Sample computations involving quadratic Pfister forms are also given. (Received September 14, 2010)

1067-12-1117 **Zev Chonoles*** (zevchonoles@gmail.com), 69 Brown Street, Box 7240, Providence, RI 02912, **John Cullinan** (cullinan@bard.edu), John Cullinan, Bard College, 30 Campus Road, Annandale-on-Hudson, NY 12504, **Hannah Hausman** (Hannah.E.Hausman@williams.edu), Bronfman Science Center, Williams College, Williamstown, MA 01267, **Allison Pacelli**, Bronfman Science Center, Williams College, Williamstown, MA 01267, **Sean Pegado**, Bronfman Science Center, Williams College, Williamstown, MA 01267, and **Fan Wei*** (fan_wei@mit.edu), 6-301, 471 Memorial Drive, Cambridge, MA 02139. *The Splitting Fields of Generalized Rikuna Polynomials.*

Fix a positive integer ℓ, and let K be any field containing $\zeta_\ell + \zeta_\ell^{-1}$ but not ζ_ℓ. Rikuna discovered a polynomial F_ℓ over the function field $K(T)$ whose Galois group is $\mathbb{Z}/\ell\mathbb{Z}$. Komatsu recently generalized classical Kummer theory to cover cyclic extensions arising from F_ℓ.

In our work, for each $m \geq 1$, we introduce the *m-th generalized Rikuna polynomial* r_m, which roughly is formed from the m-th iteration of a rational function related to F_ℓ. Let K_m be the splitting field of r_m over $K(T)$. It is known that the tower of K_m's ramifies at finitely many primes of $K(T)$.

We study the tower of K_m's. For any odd $\ell \geq 3$, we show that the Galois group $\mathrm{Gal}(K_m/K(T))$ is a semi-direct product $\mathbb{Z}/\ell^m\mathbb{Z} \rtimes \mathbb{Z}/(\ell^m/b_m)\mathbb{Z}$, where b_m is the order of a certain group of roots of unity in K_m. For even ℓ, the Galois group is one of four possibilities, depending on the field K. We also show that only one prime of $K(T)$ ramifies in the tower of K_m's, and determine this prime explicitly. Then, using the Riemann-Hurwitz formula, we prove that K_m is of genus 0, and therefore has class number 1, for all $m \geq 1$. (Received September 19, 2010)

1067-12-1319 **Cooper Boniece*** (bboniece@skidmore.edu), Skidmore College, Saratoga Springs, NY 12866, and **Gove Effinger** (effinger@skidmore.edu), Department of Math & CS, Skidmore College, Saratoga Springs, NY 12866. *Twin Irreducible Polynomials over* $\mathbf{F}_2$ *- Background.* Preliminary report.

Two monic irreducible polynomials over $\mathbf{F}_q$ with $q > 2$ are called *twins* provided they differ only in their constant coefficient. It has been proven that for all $q > 2$ there exist infinitely many twin irreducible pairs over $\mathbf{F}_q$. Over $\mathbf{F}_2$, however, twins must defined as differing only in their linear and quadratic coefficients (since their constant coefficients must be 1), and so the techniques used to establish the above results for $q > 2$ do not work. We discuss the background of this distinct and seemingly difficult case. (Received September 20, 2010)

1067-12-1324 **Cooper Boniece** (bboniece@skidmore.edu), Skidmore College, Saratoga Springs, NY 12866, and **Gove Effinger*** (effinger@skidmore.edu), Department of Math & CS, Skidmore College, Saratoga Springs, NY 12866. *Twin Irreducible Polynomials over* $\mathbf{F}_2$ *- Conjectures.* Preliminary report.

Two irreducible polynomials over $\mathbf{F}_2$ are called *twins* provided they differ only in their linear and quadratic coefficients. The aim of this research is to prove that there are infinitely many twin irreducible polynomials over $\mathbf{F}_2$. Though no proof has yet been achieved, we outline here several promising conjectures toward this end. (Received September 20, 2010)

1067-12-1494 **Paul Baginski*** (baginski@gmail.com), Institut Camille Jordan, Batiment Braconnier, Universite Claude Bernard Lyon 1, 69622 Villeurbanne, France, and **K. Grace Kennedy** (kgracekennedy@gmail.com), University of California, Santa Barbara, Santa Barbara, CA 93106. *Factorization Techniques for Numerical Semigroup Rings.*

Given a ring, $(R, +, \cdot)$, and a semigroup, $(S, +)$, one can construct a new ring, $R[S]$, called the semigroup ring. This ring generalizes the standard polynomial ring $R[X]$. Semigroup rings have been studied extensively, especially in the case where R is the integers or a field. The semigroup ring, in an intuitive sense, carries some of the factorization structure of S, but due to the interaction with R, one often gets new behavior for factorization. We will be concerned with the particular case where S is a numerical monoid. In this case, the factorization properties of the semigroup ring can be viewed as a combination of the factorization properties of the numerical monoid S and those of another monoid B, the block monoid over a particular abelian group. We will discuss the utility of this viewpoint, by considering how longest factorizations of elements can be estimated in terms of factorizations performed within B and S separately. (Received September 21, 2010)

1067-12-1908 **Gregory V. Bard*** (bard@fordham.edu), Dept of Math, John Mulcahey Hall, Fordham University, The Bronx, NY 10458. *DEMOCRACY: a new technique for solving polynomial systems of equations over finite fields via stochastic local search.* Preliminary report.

Polynomial systems of equations arise in cryptanalysis, and elsewhere. The DEMOCRACY algorithm is a new technique for finding one solution in the coefficient field, for low degree systems. First, start with a random temporary assignment of a field element to each variable. Then "erase" the value of one variable, call it x. Each equation is now a univariate polynomial, considering the unerased variables as being constants equal to their temporary assignment, and only x as unknown.

If x is never raised to a power > 3, then simple algebra is sufficient to produce a set of values for x that satisfy any particular equation in the system. The equations then "vote" for values of x, with a "ballot box" for each field element, and each equation voting for any field element that will satisfy it. It is easy to see that the box with the most votes corresponds to the coefficient field element that will satisfy the largest number of the given equations. Now x is changed to that value, and another variable is targeted.

This is a simplified version of the actual method. While extremely heuristic, this method has been effective on systems of up to 100 equations and can quickly solve systems that cause MAGMA to crash for lack of memory. (Received September 22, 2010)

1067-12-1991 **Nigel Boston** (boston@math.wisc.edu), 303 Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706, and **Meghan De Witt*** (dewitt@math.wisc.edu), 418 Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706. *The Inverse Galois Problem with minimal ramification over function fields.*

For many years, efforts have been made to solve the Inverse Galois Problem: Does every finite group G appear as a Galois group over a given field K, with special emphasis placed on the case where K is the rational numbers. We are interested in exploring what type of ramification can be expected for a given group and field, and discovering if there is some way to classify what the minimal ramification will be for a G extension of a given field K, specifically when K is a function field. We cover several cases of this situation, both theoretical and computational, and provide evidence of a conjecture that will cover the general case. (Received September 22, 2010)

1067-12-2199 **David Harbater**, **Julia Hartmann** and **Daniel Krashen*** (dkrashen@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Higher dimensional local-global principles.*

This talk will examine local-global principles for algebraic structures defined over fields of the form $K(X)$ where K is a complete discretely valued field and X/K is a curve. In particular, we will examine torsors for linear algebraic groups and the measure the failure/success of local-global principles defined with respect to different types of "more local" fields. This is joint work with David Harbater and Julia Hartmann. (Received September 22, 2010)

1067-12-2371 **Alice Medvedev*** (alice@math.berkeley.edu) and **Thomas Scanlon**. *Further applications of ACFA to polynomial dynamics.* Preliminary report.

A variety X over a field K with a selfmap $F : X \to X$ is an algebraic dynamical system. The same data code a σ-variety $(X, F)^\sharp$, definable in a large difference field (E, σ) with K contained in the fixed field of the automorphism σ. We exploit the model-theoretic properties of $(X, F)^\sharp$ to characterize invariant subvarieties of the corresponding dynamical system. This time, (X, F) will not be a product of one-dimensional polynomial dynamical systems. (Received September 22, 2010)

13 ► Commutative rings and algebras

1067-13-56 **Marcela Chiorescu*** (marcela.chiorescu@gcsu.edu), Georgia College & State University, GA , and **Fred Richman** (richman@fau.edu), Florida Atlantic University, FL. *Minimal Zero-Dimensional Extensions.*

Let R be a commutative ring with Noetherian spectrum in which zero is a primary ideal. We present the structure of minimal zero-dimensional extensions of R when every height-one prime ideal of R is contained in only finitely many prime ideals. This extends previous results for $\dim(R) \leq 1$. We also present a characterization of the poset of prime ideals in a ring with Noetherian spectrum. (Received July 01, 2010)

1067-13-167 **Harrison Craig Chapman*** (hchapman@bowdoin.edu), 106 Riverbend Dr., North Brunswick, NJ 08902, and **Malcolm E Rupert** (rupertm2@students.wwu.edu), 5603 Edgewood Place Dr., Spring, TX 77379. *Packets, Solving Symmetries and Sudoku.*

In a typical Sudoku puzzle, a number of initial clues are given, and the solver uses strategies to fill in the remaining clues to complete the board. In this talk, we shift the focus of study from clues to what we call packets. A packet gives information about what clues cannot be in a cell. Using a brute force computer search with appropriate reductions, we answer the question, "what is the minimum number of packets needed to describe a puzzle with a unique completion?" Packets are also intimately related to the Boolean system of polynomial equations used to describe the constraints of a Sudoku puzzle. We show how they can be used to more efficiently calculate a Gröbner basis of the ideal generated by this system of equations. Packets can be used to algebraically construct solving symmetries which mimic the human strategies involved in solving Sudoku puzzles. Solving symmetries are functions which manipulate a puzzle while maintaining the same solutions. We prove that these solving symmetries form a group which act on the set of Sudoku puzzles. We explore the structure of this group and discuss a long-standing open problem in Sudoku. (Received July 28, 2010)

1067-13-222 **Paul A Sundheim*** (paul.sundheim@uwc.edu), 1500 University Drive, Waukesha, WI 53188. *An Infinite System of Hypercomplex Numbers.*

A system of hypercomplex numbers is defined for each dimension that is a power of 2. In each of these dimensions, the numbers are associative and commutative but their advantages lie in the ease of multiplication, how closely their properties mirror the properties of the complex numbers in 2 dimensions as well as the location and properties of the zero divisors. In addition, the basis forms a group under multiplication providing a multiplication table that relates all of the roots of -1 and real and non-real roots of 1. Some classic geometric and analytic properties of the ring are verified. (Received August 09, 2010)

1067-13-230 **Christina L. Eubanks-Turner***, P.O. Box 41010, Lafayette, LA 70504, and **Serpil Saydam** and **Melissa Luckas**. *Prime Ideals in Birational Extensions of Two-Dimensional Power Series Rings.* Preliminary report.

In this talk we describe the *prime spectrum*, the set of prime ideals, for certain two-dimensional polynomial and power series rings. Our main result is the characterization of those partially ordered sets that arise as prime spectra of simple birational extensions of a power series ring in one indeterminate with coefficients in a countable infinite Dedekind domain that has infinitely many maximal ideals. (Received August 10, 2010)

1067-13-266 **Emily E. Witt*** (emwitt@umich.edu), Department of Mathematics, 530 Church St., Ann Arbor, MI 48109. *An example of computing local cohomology.*

If I is an ideal of a commutative ring R, the *local cohomology modules of R with support in I*, $H^i_I(R)$, are a family of R-modules indexed by nonnegative integers i; they capture many important invariants of R and I. However, often they are very large (i.e. non-finitely generated), which makes it interesting, yet challenging, to find and understand their structure. Moreover, while there are many theorems about local cohomology modules with support in the unique homogeneous ideal $\mathfrak{m}$ of a graded ring R, much less is known about the modules $H^i_I(R)$ in the case that $I \neq \mathfrak{m}$.

Let r and s be positive integers with $r \leq s$, let k be a field of characteristic zero, and let R be the polynomial ring over k in the $r \cdot s$ indeterminates x_{ij} coming from the $r \times s$ matrix $X = [x_{ij}]$. Here we study the structures of the local cohomology modules $H^i_I(R)$ in the case that I is the ideal generated by the $r \times r$ minors (the maximal minors) of X. (Received September 22, 2010)

1067-13-385 **Paolo Mantero** and **Yu Xie*** (yxie@nd.edu), 2314 Coachmans Trail, South Bend, IN 46637. *Symbolic power of some classes of algebras.* Preliminary report.

Let (R, m) be a regular local ring, $p \in \operatorname{Spec}(R)$, with R/p Cohen-Macaulay. Assume either R/p is stretched, or $e(R/p) \leq c+3$, where $c = \operatorname{ecodim}(R/p)$, or R/p is a short algebra. If R/p is not Gorenstein, then $p^{(2)} \neq p^2$. As a corollary, we have that if p/p^2 is Cohen-Macaulay, then R/p is Gorenstein. This answers Vasconcelos conjecture for some classes of algebras. (Received August 30, 2010)

1067-13-390 **Emily E Witt*** (emwitt@umich.edu), Department of Mathematics, 530 Church St, Ann Arbor, MI 48109. *Local cohomology modules as G-modules.*

Suppose that R is a polynomial over a field k of characteristic zero, and that G is a linearly reductive group acting "very nicely" on R. We make use of this action, and apply Lyubeznik's results on D-modules, to study the structure of local cohomology modules $H^i_I(R)$, where I is a certain G-stable ideal. One notable application of this result is the case when R is the polynomial ring $k[X]$, where $X = [x_{ij}]$ is an $r \times s$ $(r \leq s)$ matrix of indeterminates, and I is the ideal generated by the $r \times r$ minors (the maximal minors) of X. In this case, we find $H^N_I(R)$ for $N = \max_i\{H^i_I(R) \neq 0\}$, completely determine the indices i for which $H^i_I(R) \neq 0$, and also describe the nonzero $H^i_I(R)$ as submodules of certain indecomposable injective modules. (Received September 22, 2010)

1067-13-392 **Daniel Jesús Hernández*** (dhernan@umich.edu). *F-pure thresholds of hypersurfaces over fields of positive characteristic.*

To any polynomial over a perfect field of positive characteristic (or more generally to any principal ideal in an F-finite ring), one may associate an invariant called the F-pure threshold. This invariant, defined using the Frobenius morphism on the ambient ring, can be thought of as a positive characteristic analog of the well-known log canonical threshold in characteristic zero. In this talk, we will present some formulas for F-pure thresholds, and discuss the relationship between F-pure thresholds and log canonical thresholds. We also point out how these results are related to the longstanding open problem regarding the equivalence of (dense) F-pure type and log canonical singularities for hypersurfaces in complex affine space. (Received August 31, 2010)

1067-13-395 **Jen-Chieh Hsiao**, **Karl Schwede** and **Wenliang Zhang*** (wlzhang@umich.edu), 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Cartier Modules on Toric Varieties.*

Let (X, Δ) be a pair of an affine toric variety $X = Spec(R)$ of characteristic $p > 0$ and an effective toric divisor on X such that $K_X + \Delta$ is $\mathbb{Q}$-Cartier. Let $\phi : R \to R$ be a p^{-e}-linear map corresponding to Δ. We give complete descriptions of ideals I such that $\phi(I) = I$ in terms of the combinatorics of the underlying cone and in terms of resolutions of singularities of X. (Received August 31, 2010)

1067-13-407 **Douglas A Torrance*** (torrance@vandals.uidaho.edu), G-7 Brink Hall, Department of Mathematics, University of Idaho, Moscow, ID 83844. *Bounds on the degrees of generators of Bruns ideals.* Preliminary report.

Let $I = (f_1, \ldots, f_r)$ be a graded ideal in a polynomial ring R over a field. Stillman asked if there exists a bound on the regularity or projective dimension of R/I depending only on r and the degrees of the f_i. Bruns showed that for any such I, there exists a 3-generated J such that R/I and R/J, past a certain point, share a free resolution. Therefore, to answer Stillman's questions, we may restrict our attention to 3-generated ideals. However, we must take into account the degrees of the generators of J as they relate to the degrees of the f_i. In this talk, I examine this problem and present what is known.

This talk is based on work conducted at the 2010 Commutative Algebra Mathematical Research Communities by Dang Hop Nguyen, Wenbo Niu, Soumya Deepta Sanyal, Emily E. Witt, Yi Zhang, and the presenter. (Received September 01, 2010)

1067-13-408 **Kristen A Beck*** (kbeck@uta.edu), Department of Mathematics, The University of Texas at Arlington, P.O. Box 19408, Arlington, TX 76013. *Conditions for the existence of totally reflexive modules.* Preliminary report.

A finitely generated module M over a Noetherian ring R is called *totally reflexive* if each of the following hold:

1. $\mathrm{Ext}^i_R(M,R) = 0$ for all $i > 0$,
2. $\mathrm{Ext}^i_R(M^*,R) = 0$ for all $i > 0$, and
3. $M \cong M^{**}$ via the canonical biduality map.

In this talk, we will characterize the Hilbert series of a local ring $(R,\mathfrak{m})$ with $\mathfrak{m}^4 = 0$ which admits totally reflexive modules with linear complete resolutions. In particular, we show that if such a ring R with embedding dimension e admits certain asymmetric complete resolutions, then $H_R(t) = 1 + et + et^2 + t^3$.

We also investigate the orbits of the Auslander-Reiten translates of totally reflexive modules over finite dimensional algebras. (Received September 01, 2010)

1067-13-455 **Basak Ay***, Dept. of Mathematics, Statistics and Computer, Science, The Ohio State University at Lima, Lima, OH 45804. *Krull Schmidt Property for Ideals of Reduced Commutative Noetherian Rings.*

Let R be a reduced commutative Noetherian ring. We provide conditions equivalent to isomorphism for completely decomposable finitely generated modules over R. We show that if R is one-dimensional and R satisfies the Krull Schmidt property for ideals, then any overring of R must also have this property. We also show that if R is both local and one-dimensional satisfying the Krull Schmidt property for ideals, then it has the Krull Schmidt property for direct sums of rank one modules. (Received September 04, 2010)

1067-13-491 **Ian M. Aberbach** and **Aline Hosry*** (aline.hosry@mail.mizzou.edu), 202 Math Sciences Building, Department of Mathematics, University of Missouri, Columbia, MO 65211. *Coefficient theorems of Briançon-Skoda type.* Preliminary report.

Let (R,m) be a Noetherian local ring, $I \subseteq R$ an ideal of analytic spread ℓ and let $J \subseteq I$ be a reduction of I. When R is a "nice" ring, the Briançon-Skoda Theorem implies that $\overline{I^\ell} \subseteq J$. Hence any element of $\overline{I^\ell}$ is a linear combination of the generators of J with coefficients in R. Under certain hypotheses, one can get some information on those coefficients, or show that there exists $k < \ell$ with $\overline{I^k} \subseteq J$. In this talk, we will survey several results in this direction and show that some previous work can be improved. (Received September 06, 2010)

1067-13-625 **Laura R Lynch*** (s-llynch1@math.unl.edu). *Annihilators of Local Cohomology.* Preliminary report.

In many important theorems in the homological theory of commutative local rings, an essential ingredient in the proof is to consider $\mathrm{Ann}_R H^i_I(R)$. We examine these annihilators when i is the cohomological dimension of I and give an explicit description when the cohomological dimension coincides with either the grade of I or the dimension of R. We also examine these annihilators over local noetherian domains and show the annihilator is zero under certain restrictions. (Received September 12, 2010)

1067-13-672 **Melissa Lindsey***, Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47907. *Extending the Strong Lefschetz Property.*

Let k be a field of characteristic zero, and let $R = k[x_1, \ldots, x_n]$ be a standard graded polynomial ring in n variables over k. For M, a finitely generated zero-dimensional R-graded module with the strong Lefschetz property, we introduce a new property of the Hilbert function, the *almost centered property*. We show that $M \otimes_k k[y]/(y^m)$ has the strong Lefschetz property for y an indeterminate and all positive integers m if and only if the Hilbert function of M has the almost centered property. This result gives a new proof of Stanley's theorem that $k[x_1, \ldots, x_n]/(x_1^{a_1}, \ldots, x_n^{a_n})$ has the strong Lefschetz property. We also discuss what happens in the case where the characteristic of the field is positive. (Received September 13, 2010)

1067-13-800 **Linh Cao Huy*** (huylinh2002@yahoo.com), 8861 Burning Tree Rd., Pensacola, FL 32514, and **Brodmann Markus**. *Castelnuovo-Mumford regularity and relation type.*

In this talk, we will establish a bound for the Castelnuovo-Mumford regularity of associated graded rings with respect to parameter ideals in terms of dimension and relation type. From this it follows that R has a uniform bound on relation type of parameter ideals if and only if R has a uniform bound on regularity of parameter ideals. (Received September 14, 2010)

1067-13-856 **Jason McCullough*** (jmccullo@math.ucr.edu). *Lifting Splittings and the Strong Direct Summand Conjecture.*

Let (R, m) be a regular local ring and let A be a module-finite extension of R. Let $x \in m - m^2$ and let Q be a height one prime of A lying over xR. Ranganathan's Strong Direct Summand Conjecture states that the inclusion $xR \to Q$ splits as a map of R-modules. This problem is connected with the the other Homological Conjectures including Hochster's Direct Summand Conjecture and the Vanishing Conjecture on Maps of Tor. We prove some special cases of the conjecture and give a new proof that the Vanishing Conjecture implies the Strong Direct Summand Conjecture. (Received September 15, 2010)

1067-13-879 **Gyu Whan Chang**, **Byung Gyun Kang** and **Jung Wook Lim*** (lovemath@postech.ac.kr), Department of Mathematics POSTECH, San 31 Hyoja-Dong Nam-Gu, Pohang, Kyungpook 790-784, South Korea. *Characterizations of various integral domains of the form $A + B[\Gamma^*]$.* Preliminary report.

Let $A \subseteq B$ be an extension of integral domains, S be a (saturated) multiplicative subset of A and Γ be a nonzero torsion-free (additive) grading monoid. In this talk, we characterize Prüfer v-multiplication domains and related domains of the form $R = A + B[\Gamma^*]$. In particular, we study the domain R when $B = A_S$.

This is a joint work with Chang and Kang. (Received September 15, 2010)

1067-13-880 **Nicholas J. Werner*** (werner@math.osu.edu), Department of Mathematics, The Ohio State University, 231 West 18th Ave, Columbus, OH 43210. *Integer-valued Polynomials over Noncommutative Rings.*

When D is an integral domain with field of fractions K, the ring $\mathrm{Int}(D) := \{f(x) \in K[x] \mid f(d) \in D$ for all $d \in D\}$ of integer-valued polynomials over D has been extensively studied. Rings of integer-valued polynomials can also be constructed over some noncommutative rings; in particular, they may be defined for matrix rings and group algebras over the rational integers. This talk will give an overview of this topic, focusing on the similarities and differences between the commutative and noncommutative cases. (Received September 15, 2010)

1067-13-907 **Adam Salminen*** (as341@evansville.edu), 1800 Lincoln Avenue, Evansville, IN 47714, and **Greg Oman**. *On modules whose proper homomorphic images are of smaller cardinality.*

Let R be a commutative ring with identity, and let M be a unitary module over R. We call M H-smaller (HS for short) iff M is infinite and $|M/N| < |M|$ for every nonzero submodule N of M. We give a characterization of HS modules, and answer an open question on Jónsson modules. (Received September 16, 2010)

1067-13-942 **Julian David Chan*** (julian@math.utah.edu), 477 H street, Salt Lake City, UT 84103. *Torsion of Cohomology Modules.*

Huneke asked if local cohomology modules have only finitely many associated primes. If R is a regular ring containing a field of prime characteristic, then Huneke and Sharp showed the set of associated primes is finite. Lyubeznik showed that the set of associated primes is again finite if R is a regular local ring of characteristic zero. Singh and Katzman have given examples of cohomology modules each with an infinite set of associated primes. Equivalently, Singh has shown that for each prime integer p, Z/pZ embeds into the cohomology module. We show that each finitely generated abelian group embeds into a graded component of the cohomology module. (Received September 16, 2010)

1067-13-1071 **Lori A McDonnell*** (s-lmcdonn1@math.unl.edu), 3843 S. 48th St. APT 6, Lincoln, NE 68506. *The Second Hilbert Coefficient of a Parameter Ideal in an Unmixed Ring.*

In recent work, Ghezzi, Goto, Hong, Ozeki, Phuong, and Vasconcelos showed that an unmixed ring R is Cohen-Macaulay if and only if the first Hilbert coefficient satisfies $e_1(Q) = 0$ for some parameter ideal Q of R. Inspired by this result, we will look at what conclusions can be drawn when the second Hilbert coefficient, $e_2(Q)$, is zero for a parameter ideal Q. In particular, we will discuss the following result:

Theorem Let R be an unmixed Noetherian ring of dimension $d \geq 2$. Suppose that depth $R \geq d - 1$ and let Q be a parameter ideal for R. Then the following hold:

(1) $e_2(Q) \leq 0$

(2) $e_2(Q) = 0$ if and only if $H_Q(n) = P_Q(n)$ $\forall n \geq 2 - d$ and grade $gr_Q(R)_+ \geq d - 1$

(3) $e_2(Q) = 0$ implies $e_3(Q) = e_4(Q) = \cdots = e_d(Q) = 0$.

(Received September 17, 2010)

1067-13-1087 **Aline Hosry**, **Young Su Kim** and **Javid Validashti*** (jvalidas@math.ku.edu).
Equality of Powers and Symbolic Powers of Ideals.

Let R be a ring. For a positive integer n, the n-th symbolic power of a prime ideal P is defined as $P^{(n)} = P^n R_P \cap R$. It is clear from the definition that $P^n \subseteq P^{(n)}$, but they need not be the same in general. Therefore, one would like to have conditions that imply the equality. The following question was posed by Huneke in this regard: Let R be a regular local ring of dimension d and P a prime ideal of height $d-1$. If $P^n = P^{(n)}$ for all $n \leq d-1$, then is $P^n = P^{(n)}$ for all n? We provide supporting evidences of a positive answer for classes of prime ideals defining monomial curves or having low multiplicities. (Received September 18, 2010)

1067-13-1152 **Bethany Ann Kubik*** (bethany.kubik@ndsu.edu), NDSU Mathematics Dept #2750, PO Box 6050, Fargo, ND 58108-6050, **Sean Sather-Wagstaff** (sean.sather-wagstaff@ndsu.edu), NDSU Mathematics Dept #2750, PO Box 6050, Fargo, ND 58108-6050, and **Micah J Leamer** (s-mleamer1@math.unl.edu), University of Nebraska-Lincoln, Department of Mathematics, 232 Avery Hall 880130, Lincoln, NE 68588-0130. *Matlis Duals of Ext-Modules.* Preliminary report.

Let R be a local ring and let $M^\vee$ denote the Matlis dual of an R-module M. Given R-modules M and M', Hom-tensor adjointness provides an isomorphism $\mathrm{Tor}_i^R(M,M')^\vee \cong \mathrm{Ext}_R^i(M,M'^\vee)$. Finding similar descriptions of $\mathrm{Ext}_R^i(M,M')^\vee$ requires a subtler approach. Belshoff shows that if M and M' are Matlis reflexive, then $\mathrm{Ext}_R^i(M,M')$ and $\mathrm{Tor}_i^R(M,M')$ are Matlis reflexive and $\mathrm{Ext}_R^i(M,M')^\vee \cong \mathrm{Tor}_i^R(M,M'^\vee)$. We extend these results to certain situations where M and M' are not necessarily Matlis reflexive. (Received September 19, 2010)

1067-13-1177 **Tai Ha*** (tha@tulane.edu), Tulane University, Department of Mathematics, 6823 St. Charles Avenue, New Orleans, LA 70118. *Asymptotic linearity of regularity and a*-invariant of powers of ideals.*

Let $X = \mathrm{Proj}\ R$ be a projective scheme and let $I \subseteq R$ be a homogeneous ideal. It is known that the regularity and the a*-invariant of I^n are asymptotically linear functions for n large. In this talk, I will discuss how the free constants of these functions can be related to collections of local data associated to fibers of certain projection map from the blowup of X. (Received September 19, 2010)

1067-13-1210 **Manoj Kummini*** (nkummini@math.purdue.edu) and **Uli Walther** (walther@math.purdue.edu). *Bounds for arithmetic rank.*

We will describe some bounds for the arithmetic rank of monomial ideals. (Received September 20, 2010)

1067-13-1223 **Nicholas R Baeth*** (baeth@ucmo.edu), WCM 213, University of Central Missouri, Warrensburg, MO 64093. *Irreducible Divisor Graphs.*

Introduced to provide insight into factorization properties within a commutative ring, irreducible divisor graphs have now been generalized to study factorization properties in commutative monoids. Given an element x in a commutative monoid M, the irreducible divisor graph $G(x)$ has a vertex set consisting of all irreducible elements that divide x and edge set consisting of pairs a, b of irreducible elements such that the product ab divides x. Much of the work in this area has focused on the property of gleaning information about the factorization properties of an element x in the monoid given the irreducible divisor graph $G(x)$. Recently, various irreducible divisor graphs have been constructed with certain graph-theoretic properties in mind. In this talk we will provide a brief introduction to irreducible divisor graphs, give a summary of what is known, and provide a list of open problems in this area, many of which are suitable for undergraduate research. (Received September 20, 2010)

1067-13-1239 **Craig Huneke*** (huneke@math.ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045. *Applications of graded integral closures.* Preliminary report.

This talk will focus on two recent uses of an old construction, due to Hochster and myself, of a graded absolute integral closure which is Cohen-Macaulay in positive characteristic. In work with H. Ananthnarayan, we used this to prove some results on the 3-standardness of the maximal ideal, while in joint work with S. Takagi and K. Watanabe, we used the graded absolute integral closure to prove a conjecture of Mustata in some cases. (Received September 20, 2010)

1067-13-1281 **Manuel Blickle** and **Karl Schwede*** (kschwede@umich.edu), Department of Mathematics, Pennsylvania State University, University Park, PA 16802, and **Kevin Tucker**. *F-signature of pairs.*

The F-signature is a fundamental measure of the singularities of a local ring R of characteristic $p > 0$. Explicitly, it measures the number of copies of R that a direct sum decomposition of R^{1/p^e} has, as e increases. It is closely related to the notion of F-regularity.

In this talk, we discuss the generalization of the F-signature to a pair (R, Δ) where Δ a some $\mathbb{Q}$-divisor. This generalization is natural since concepts like F-regularity have long since been generalized to this context. Pairs are useful because, given a morphism of rings $R \to S$, they allow one to study the singularities of R by studying the singularities of a certain pair on S (which may be easier). This technique also allows us to answer an open question of Aberbach and Enescu related to the F-signature and the splitting prime. (Received September 20, 2010)

1067-13-1294 **Roger A Wiegand*** (rwiegand@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Brauer-Thrall theorems and conjectures for commutative local rings.*

The Brauer-Thrall Conjectures, originally formulated in terms of representations of finite-dimensional algebras, have been successfully transplanted to the representation theory of commutative local rings. This talk will be a survey of such results, conjectures and counterexamples, for various categories of finitely generated modules over a commutative Noetherian local ring. (Received September 20, 2010)

1067-13-1341 **Craig Huneke** and **Shunsuke Takagi*** (stakagi@math.mit.edu), Department of Mathematics, Massachusetts Institute of Technology, 77 Massachusetts Ave. Room 2-230, Cambridge, MA 02139, and **Kei-ichi Watanabe**. *On parameter F-jumping numbers.*

A parameter F-jumping number is a value of the coefficient at which the parameter test submodule, a positive characteristic analog of multiplier submodules, makes a jump. We study its properties and compare this invariant with another positive characteristic invariant, called F-thresholds. Also, we give a lower bound for the parameter F-jumping number associated to homogeneous parameter ideals in terms of their multiplicities. (Received September 20, 2010)

1067-13-1758 **Hamid Kulosman***, Department of Mathematics, University of Louisville, Louisville, KY 40292. *Some properties of term ideals.*

We talk about some properties of term ideals of the R-algebra $A = R[X_1, \ldots, X_n]$ of polynomials over R in n variables $X_1, \ldots, X_n$, where R is a commutative Noetherian ring. (Received September 21, 2010)

1067-13-1765 **Susan Marie Cooper*** (scooper4@math.unl.edu), Department of Mathematics, University of Nebraska–Lincoln, Lincoln, NE 68588-0130, and **Stephen G Hartke** (hartke@math.unl.edu), Department of Mathematics, University of Nebraska–Lincoln, Lincoln, NE 68588-0130. *Relating Initial Degrees of Symbolic and Regular Powers.* Preliminary report.

Over many years, numerous algebraic tools have been developed to gain insight into 0-dimensional schemes. In particular, the Hilbert function and initial degree of the homogeneous ideal of the scheme have played central roles in attacking many intriguing problems. Although Hilbert functions of ideals defining reduced 0-dimensional schemes are well understood, much less is known about symbolic powers of such ideals (which define non-reduced schemes called fat point schemes). Recently, work of Harbourne and Huneke suggests a conjectural relationship between the initial degrees of symbolic and regular powers of homogeneous ideals. In this talk we will discuss this conjecture in the geometric setting with ideals of fat point schemes. A first step will involve applying bounds (described by Cooper-Harbourne-Teitler) for Hilbert functions of fat point schemes. This is joint work with S. G. Hartke. (Received September 21, 2010)

1067-13-1777 **Witold Kraskiewicz**, Instytut Matematyki UMK, ul. Chopina 12/18, 87100 Torun, Poland, and **Jerzy Weyman***, 360 Huntington Av., Boston, MA 02115. *Finite free resolutions of varieties with symmetries.* Preliminary report.

Let g be a simple Lie algebra, and α in g a simple root. The root α defines a grading on g. We are interested in the action of group G_0 of the Lie algebra g_0 on the space g_1. Such representations are closely related to irreducible representations of simple Lie algebras with finitely many orbits. It is well known that the action of $G_0 \times C^*$ on g_1 has finitely many orbits. By using geometric invariant theory we calculate Hilbert polynomials of (normalizations) of orbit closures. In many cases we can deduce normality, Cohen–Macaulay and Gorenstein properties of the orbit closures. This technique gives several cases of interesting pure resolutions. I will also describe the link of such constructions to the structure theorems on finite free resolutions of length three. (Received September 21, 2010)

1067-13-1812 **Wenbo Niu*** (wniu2@uic.edu), 2817 S. Union Ave. Apt.1R, Chicago, IL 60616.
Asymptotic Regularity of Powers of Ideal Sheaves.

Let $\mathcal{I}$ be an ideal sheaf on P^n. We bound the asymptotic regularity of powers of $\mathcal{I}$ as $ps-3 \leq \text{reg}\mathcal{I}^p \leq ps+e$, where e is a constant and s is the s-invariant of $\mathcal{I}$. We also give the same upper bound for the asymptotic regularity of symbolic powers of $\mathcal{I}$ under some conditions. (Received September 21, 2010)

1067-13-1888 **Michael Axtell**, **Nicholas Baeth**, **Shane Redmond** and **Joe Stickles, Jr.*** (jstickles@millikin.edu), 1184 W. Main St., Decatur, IL 62522. *Cut Sets of Zero-Divisor Graphs of Commutative Rings.*

Zero-divisor graphs of commutative rings are constructed to help illuminate algebraic structure of a ring via graph theory, and they have received much attention in the literature over the past decade. In this talk, we investigate properties of cut sets of zero-divisor graphs of commutative rings and discuss some algebraic information that can be gleaned from these sets. (Received September 22, 2010)

1067-13-1971 **Christina Eubanks-Turner**, **Melissa Luckas** (s-mluckas1@math.unl.edu), **A Serpil Saydam** and **Sylvia M Wiegand*** (swiegand@math.unl.edu), Math. Dept., Univ. of Nebraska, Lincoln, NE 68588-0130. *Prime ideals in birational extensions of power series rings.* Preliminary report.

Let R be a one-dimensional Noetherian domain, let x be an indeterminate over R and let f, g be an $R[[x]]$-sequence. In certain circumstances we describe the prime ideal structure of $R[[x]][g/f]$. (Received September 22, 2010)

1067-13-2118 **Lance Bryant*** (lebryant@ship.edu), Mathematics Department, Shippensburg University, 1871 Old Main Dr, Shippensburg, PA 17257, and **James Hamblin** and **Lenny Jones**.
Unique Maximal-Length Factorization in Numerical Semigroups. Preliminary report.

A numerical semigroup $S = \langle n_1, n_2, \ldots, n_t\rangle$ is a subset of the natural numbers including 0 such that $0 \in S$, S is closed under addition, and S has finite complement in the natural numbers. We say $n_1, n_2, \ldots, n_t$ are the minimal generators of S, i.e., $S = \{\sum c_i n_i \,|\, c_i \geq 0\}$ and any other set of generators contains this set. An element $s \in S$ may be able to be expressed as a nonnegative linear combination of the minimal generators (called a factorization) in several ways. A maximal-length factorization is one that requires the most minimal generators. For example, in $S = \langle 7, 10, 13\rangle$, we have $62 = 10+13+13+13+13 = 7+7+7+7+7+7+10+10 = 7+7+7+7+7+7+7+13$. Thus 62 has three factorization and the last two are maximal-length factorizations. This talk will focus on maximal-length factorizations when S has three minimal generators with particular interest in when every element of S has exactly one maximal-length factorization. (Received September 22, 2010)

1067-13-2229 **Jared L Painter*** (jlpainter@uta.edu), 411 S. Nedderman Drive, Department of Mathematics, Arlington, TX 76019-0408. *Tendencies of Trivariate Monomial Resolutions.* Preliminary report.

We will explore some specific properties admitted by the free resolutions over S of $R = S/I$ where $S = k[x, y, z]$, k a field and I is a monomial ideal. The main focus will be resolutions where I is primary to the homogeneous maximal ideal, so that R is Cohen-Macaulay. Specifically, we will identify certain characteristics of the last matrix of these resolutions. These characteristics pertain to the question of whether the first Bass number of R is always larger than the zeroth. (Received September 22, 2010)

14 ► Algebraic geometry

1067-14-42 **Xiao Xiao*** (xiao@math.binghamton.edu), Department of Mathematical Sciences, Library North 2200, Binghamton University, Binghamton, NY 13902. *Some new results on invariants of F-crystals.*

Let k be an algebraically closed field of characteristic $p > 0$. Let X be a projective smooth variety over k. The n-th crystalline cohomology of X is a pair (M, F) where M is a finitely generated $W(k)$-module and F is a Frobenius linear endomorphism of M. The crystalline cohomology contains more information than the usual Betti cohomology thanks to the extra Frobenius linear endomorphism F. When M is free, the pair (M, F) is called an F-crystal. Vasiu proved (2006) that for each F-crystal (M, F) there exists a smallest non-negative integer n such that (M, F) is determined by its F-truncation of level n (roughly speaking by the pair $(M/p^nM, F)$).

Therefore to classify these objects, we can follow the following two steps: (i) Fix a Hodge polygon and a Newton polygon, compute the n number of the resulting family of F-crystals over k; (ii) classify the F-truncation of (M, F) of level s for all $0 < s < n + 1$. Step (ii) is easier than classifying F-crystals directly especially when s is small. In this talk, I will give an estimate of the n number in the most general case and actually compute it in some special cases, e.g. F-crystals of K3 surfaces type, and when rank of M is 2. Applications to K3 surfaces over k will be mentioned. (Received June 11, 2010)

1067-14-133 **Jennifer Elyse Bonsangue*** (jennifer.bonsangue@csuci.edu), One University Drive, CSU Channel Islands, Camarillo, CA 93012, and **Ivona Grzegorczyk**. *Visualizing Cubic Algebraic Surfaces.*

Algebraic surfaces are the collection of points satisfying a finite number of polynomial equations. In the case of degree three surfaces, the question of classification is an open problem. We visualize these surfaces using modern software and study their properties (such as a singularities, symmetry groups, deformations, families, lines and curves lying on these surface). In particular, we analyze Cayley's nodal surface and Clebsch's cubic. By studying the effects of their deformations, we attempt to identify properties of features that may be indicative of possible classes. (Received July 27, 2010)

1067-14-169 **Dagan Karp** and **Dhruv Ranganathan*** (dhruv_ranganathan@hmc.edu), 340 East Foothill Boulevard, Claremont, CA 91711, and **Paul L Riggins** (priggins@hmc.edu), 10800 Larrylyn Dr., Whittier, CA 90603. *Toric Symmetry in Gromov-Witten Theory and Enumerative Geometry: Blowups of Complex Projective Space.*

We study manifestations of toric symmetry in Gromov-Witten theory. In particular, we study the symmetries of toric blowups of complex projective space $\mathbb{CP}^3$, including the cyclohedron, associahedron and permutohedron, all graph associahedra, as well as other toric blowups of $\mathbb{CP}^3$. In general, a symmetry of a toric variety yields an automorphism in cohomology which lifts to the level of Gromov-Witten theory, and nontrivial automorphisms yield nontrivial relations in GW theory. We identify new nontrivial relations and discuss enumerative significance. (Received July 28, 2010)

1067-14-174 **Jose Luis Gonzalez*** (jgonza@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *Cox rings and pseudoeffective cones of projectivized toric vector bundles.*

Projectivized toric vector bundles are a large class of rational varieties that share some of the pleasant properties of toric varieties and other Mori dream spaces. Hering, Mustaţă and Payne proved that the Mori cones of these varieties are polyhedral and asked whether their Cox rings are indeed finitely generated. In this talk we give a complete answer to this question. There are now several proofs of a positive answer in the rank two case [Knop, Hausen-Süß, Gonzalez]. For any rank greater than two we present projectivized toric vector bundles for which the Cox ring and the pseudoeffective cones can be identified with those of the projective space blown up at a finite set of points of our choice [Gonzalez-Hering-Payne-Süß]. This yields many new examples of Mori dream spaces, as well as examples of projectivized toric vector bundles where the pseudoeffective cone is not polyhedral and the Cox ring is not finitely generated. (Received July 28, 2010)

1067-14-177 **Daniel Moore*** (djmoore@cs.hmc.edu) and **Dmitri Skjorshammer**. *Picard-Fuchs Equations for a Family of K3 Hypersurfaces.*

String theory, an attempt to unify the theories of general relativity and quantum mechanics, supposes that the Universe contains several extra dimensions wrapped up in complex shapes called Calabi-Yau varieties. We consider Calabi-Yau varieties realized as hypersurfaces in toric varieties, which can be constructed from fans in $\mathbb{R}^n$; these fans can in turn be constructed from polytopes. In addition to developing computational methods for measuring properties of hypersurfaces, including quasi-smoothness and regularity,we studied a particular family of K3 surfaces in a toric variety constructed from an octahedron in $\mathbb{R}^3$. We computed the Picard-Fuchs differential equation for this family; this equation describes the complex structure of a family of varieties. The equation we computed is consistent with known results. (Received July 28, 2010)

1067-14-178 **Dmitri Skjorshammer*** (dmitriskj@gmail.com), 340 East Foothill Blvd, Claremont, CA 91711. *Classification of Tops in Five Dimensions.*

Reflexive polytopes are important in mathematical string theory because they can be used to generate and study Calabi-Yau varieties arising as complete intersections in toric varieties defined by the reflexive polytopes. Kreuzer and Skarke classified all reflexive polytopes for $n \leq 4$ but $n = 5$ remains open. One way to study five-dimensional reflexive polytopes is to study slices, which are reflexive polytopes obtained by intersecting the polytope with a hyperplane. Of interest to us are the "tops" that slices generate, which encode information about the polytope, and the fibrations that slices induce. We study the tops and induced fibration structures on the corresponding toric varieties and families of Calabi-Yau hypersurfaces. (Received July 28, 2010)

1067-14-290 **Kiana L Ross*** (klross@math.washington.edu), 5850 57th Avenue NE, Seattle, WA 98105. *Characterizations of Projective Spaces and Smooth Quadric Hypersurfaces via $\wedge^p T_X$.*

Since Mori's proof of the Hartshorne conjecture, there have been many results in the literature using positivity properties of T_X to characterize $\mathbb{P}^n$. Despite similarities, the current results are incongruous in the sense that none of them implies all the others. The following conjecture is appealing since it generalizes all current results, including Mori's original theorem:

(Kovács Conjecture.) *Let X be a smooth complex projective variety of dimension n, $\mathcal{E}$ an ample vector bundle of rank r, and $p \le r$ a positive integer such that $\wedge^p \mathcal{E} \subseteq \wedge^p T_X$. Then either $X \simeq \mathbb{P}^n$ or $X \simeq Q_p \subseteq \mathbb{P}^{p+1}$, where Q_p is a smooth quadric hypersurface.*

I will present a proof of the Kovács conjecture for varieties with Picard number 1. The main technique is to study the behavior of certain families of rational curves on X. Roughly speaking, positivity of T_X implies that X is covered by rational curves, i.e., X is *uniruled*. The global geometry of X is encoded in these rational curves. I will discuss techniques used to translate information about rational curves into information about the geometry of X. (Received August 16, 2010)

1067-14-293 **Ha N Nguyen*** (hnguyen@wesleyancollege.edu), 4760 Forsyth Road, Macon, GA 31210. *Polynomials Nonnegative on Half-strips and Multiple Strips.*

Recently, M. Marshall answered a long-standing question in real algebraic geometry by showing that if $f \in \mathbb{R}[x, y]$ and $f \ge 0$ on the strip $[0, 1] \times \mathbb{R}$, then f has a representation $f = \sigma_0 + \sigma_1 x(1 - x)$, where $\sigma_0, \sigma_1 \in \mathbb{R}[x, y]$ are sums of squares.

In this talk, we give some background to Marshall's result, which goes back to Hilbert's 17th problem, and our generalizations to half-strips and strips of $\mathbb{R}^2$. (Received August 16, 2010)

1067-14-381 **David Jensen*** (djensen@math.utexas.edu), SUNY Stony Brook Department of Mathematics, 100 Nicolls Road, Stony Brook, NY 11794-3651. *Beyond the Boundary: Log Minimal Models for the Moduli Space of Curves.*

Recent work of Hassett and Hyeon has described the first few stages of the log minimal model program for the moduli spaces of curves. These models agree with the moduli space on the interior – in each, a subset of the boundary is contracted or flipped. We will discuss progress toward birational models that affect the interior. (Received August 30, 2010)

1067-14-418 **Milagros Izquierdo*** (milagros.izquierdo@liu.se), Department of Mathematics, Linköping University, 581 83 Linköping, Sweden, and **Antonio F Costa** (acosta@mat.uned.es). *Disconnectedness of Singular Loci of Moduli Spaces of Complex Curves.*

The moduli space $\mathcal{M}_g$ of compact Riemann surfaces of genus g has the structure of an orbifold and the set of singular points of such orbifold is the *branch locus* $\mathcal{B}_g$. In this article we study the connectivity of $\mathcal{B}_g$. More concretely we prove that $\mathcal{B}_g$ is disconnected for $g \ge 26$. In a final remark we present the known information about this problem for genera < 26. (Received September 02, 2010)

1067-14-458 **Shin-Yao Jow*** (jows@math.upenn.edu), University of Pennsylvania, Department of Mathematics, 209 South 33rd Street, Philadelphia, PA 19104-6395. *The effective cone of the space of parametrized rational curves in Grassmannians.* Preliminary report.

We will describe the effective cone of the Quot scheme parametrizing all degree d, rank r quotient sheaves of the trivial vector bundle of rank n on $\mathbb{P}^1$. This Quot scheme is a nonsingular projective compactification of the scheme $\mathrm{Hom}_d(\mathbb{P}^1, \mathrm{Gr}(r, n))$ parametrizing morphisms of degree d from $\mathbb{P}^1$ to the Grassmannian $\mathrm{Gr}(r, n)$. (Received September 05, 2010)

1067-14-572 **Scott R Nollet*** (s.nollet@tcu.edu), 3521 Stadium Drive, Fort Worth, TX 76109. *Picard groups of normal surfaces.* Preliminary report.

In recent work, we proved that if $Z \subset \mathbb{P}^3$ is of dimension one and generic embedding dimension at most two with ideal sheaf generated by global sections in degree d, then the general surface S of degree greater than maxd,4 containing Z is normal with class group freely generated by $\mathcal{O}_S(1)$ and the supports of the curve components of Z

(when Z is empty, this recovers the Noether-Lefschetz theorem). Since Picard groups are of more interest, we have computed them for these surfaces in various typical circumstances. The answer depends on the singularities of S and their local Picard groups. I expect to give a few examples that illustrate our method. (Received September 10, 2010)

1067-14-573 **Franz Winkler*** (franz.winkler@risc.jku.at), RISC, J. Kepler University, Altenbergerstr. 69, A-4040 Linz, Austria. *Existence and computation of rational general solutions of parametrizable ODEs.*

Consider an autonomous ODE of the form $F(y, y') = 0$, where F is a bivariate polynomial. We can think of F as defining a plane algebraic curve. If this curve admits a rational parametrization, then we can determine whether the ODE has a rational general solution. Based on degree bounds for such parametrizations by Sendra and Winkler, Feng and Gao have described an algorithm for this problem.

Here we consider the case of a non-autonomous ODE of the form $F(x, y, y') = 0$. The tri-variate polynomial F defines an algebraic surface, which we assume to admit a rational parametrization. Based on such a parametrization and on knowledge about a degree bound for general rational solutions, we can determine the existence of a general rational solution, and, in the positive case, also compute one. (Received September 10, 2010)

1067-14-634 **David J Swinarski*** (davids@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Vector bundles of conformal blocks.* Preliminary report.

The WZW model of conformal field theory gives rise to vector bundles on the moduli spaces of curves $\overline{\mathcal{M}}_{g,n}$. These were first constructed in the 1980s by Tsuchiya, Ueno, and Yamada and received a great deal of attention in the 1990s in connection with the Verlinde formula. Recently, Fakhruddin (2010) gave formulas for the Chern classes of these bundles. These have been implemented by Swinarski in a Macaulay 2 package called ConfBlocks. I will discuss experimental results, theorems, and new questions that have come out of this. This is joint work with Valery Alexeev and Angela Gibney. (Received September 12, 2010)

1067-14-656 **Angela Gibney*** (agibney@uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602, and **Valery Alexeev** and **David Swinarski**. *Conformal Blocks Divisors on $\overline{M}_{0,n}$.*

Given a simple Lie algebra $\mathfrak{g}$, a positive integer ℓ called the level, and an appropriately chosen n-tuple of dominant integral weights $\overline{\lambda}$ of level ℓ, one can define a vector bundle on the moduli spaces $\overline{M}_{g,n}$ whose fibers are the so-called vector spaces of conformal blocks. On $\overline{M}_{0,n}$, first Chern classes of these vector bundles turn out to be nef divisors. In this talk I will discuss the simplest examples of these divisors, and point out some of the interesting features about them discovered in joint work with Alexeev and Swinarski. (Received September 13, 2010)

1067-14-658 **Hongbo Li*** (hli@mmrc.iss.ac.cn), Key Laboratory of Mathematics Mechanization, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, Beijing 100190, Peoples Rep of China. *On the Number of Erdös' Consistent 5-tuples.*

Around 1994, Erdös et al. proposed the following challenging problem in enumerative projective incidence geometry, called consistent 5-tuple problem:

"For ten points a_{ij}, $1 \le i < j \le 5$, in the projective plane, if there are five points a_k, $1 \le k \le 5$, in which at least two points are different, such that a_i, a_j, a_{ij} are collinear for all $1 \le i < j \le 5$, we say the five points form a consistent 5-tuple. Now assume that no three of the a_{ij} are collinear. Is it true that there are only finitely many consistent 5-tuples?"

This talk is on the following theorems proved by us with Cayley expansion and Cayley factorization techniques:

Theorem 1. For 10 generic points $\{a_{ij} \,|\, 1 \le i < j \le 5\}$ in the plane, any consistent 5-tuple $\{a_k \,|\, 1 \le k \le 5\}$ satisfies:

(1) $a_i \ne a_j$ for $i \ne j$.
(2) $a_i \ne a_{ij}$ for $i \ne j$.
(3) $a_i \ne a_{jk}$ for $i \ne j \ne k$.
(4) a_i, a_{ij}, a_{ik} are noncollinear for $i \ne j \ne k$.
(5) a_i, a_{ij}, a_{jk} are noncollinear for $i \ne j \ne k$.

If any of the above conditions is violated, there are only finitely many consistent 5-tuples.

Theorem 2. For 10 generic points $\{a_{ij} \,|\, 1 \le i < j \le 5\}$ in the plane, there are at most 6 consistent 5-tuples. (Received September 13, 2010)

1067-14-671 **Jack Huizenga*** (huizenga@math.harvard.edu), Harvard University, Department of Mathematics, 1 Oxford St, Cambridge, MA 02143. *Interpolation on surfaces in $\mathbb{P}^3$.*

Suppose S is a surface in $\mathbb{P}^3$, and $p_1, \ldots, p_r$ are general points on S. What is the dimension of the space of sections of $\mathcal{O}_S(e)$ having singularities of multiplicity m_i at p_i for all i? This question is a natural analog of an important long-open question for $\mathbb{P}^2$. We present two natural equivalent conjectures which would answer this question. We then indicate how to use a degeneration argument to prove these conjectures in case all multiplicities are at most 4. (Received September 13, 2010)

1067-14-685 **Eric Edward Katz*** (eekatz@math.utexas.edu), 1 University Station C1200, Austin, TX 78712-0257. *Lifting Tropical Curves and Linear Systems on Graphs.*

Tropicalization is a procedure for associating a polyhedral complex to a subvariety of an algebraic torus. We study the question on which graphs arise from tropicalizing algebraic curves. By using Baker's technique of specialization of linear systems from curves to graphs, we are able to give a necessary condition for a balanced weighted graph to be the tropicalization of a curve. Our condition reproduces a generalization of Speyer's well-spacedness condition and also gives new conditions. (Received September 13, 2010)

1067-14-696 **June Huh*** (huh14@illinois.edu), Mathematics department, University of Illinois, Urbana, IL 61801. *Milnor numbers of projective hypersurfaces and the chromatic polynomial of graphs.*

The chromatic polynomial of a graph G counts the number of proper colorings of G. We give an affirmative answer to the conjecture of Read and Rota-Heron-Welsh that the absolute values of the coefficients of the chromatic polynomial form a log-concave sequence. We define a sequence of numerical invariants of projective hypersurfaces analogous to the Milnor number of local analytic hypersurfaces. Then we show log-concavity of the sequence which includes the conjecture on the chromatic polynomial as a special case. As a byproduct of our approach, we obtain an analogue of Kouchnirenko's theorem relating the Milnor number with the Newton polytope; we also answer a question posed by Trung-Verma. (Received September 13, 2010)

1067-14-711 **Will Traves*** (traves@usna.edu), Math Dept, Mail Stop 9E, USNA, Annapolis, MD 21402, and **Max Wakefield** (wakefiel@usna.edu). *Families of free hyperplane arrangements.* Preliminary report.

This is a preliminary report. We are motivated by Terao's conjecture: the combinatorial lattice type determines the freeness of a hyperplane arrangement. To this end, we explore the underlying reasons that exponents may change as we move in a family of free hyperplane arrangements. (Received September 13, 2010)

1067-14-789 **Yusuf Mustopa*** (ymustopa@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Ulrich bundles on del Pezzo surfaces.*

Ulrich bundles occur naturally in a variety of algebraic and algebro-geometric topics, including determinantal and Pfaffian descriptions of hypersurfaces, the computation of resultants, and the representation theory of generalized Clifford algebras. In this talk I will discuss the connection between the existence of rank r Ulrich bundles on a degree-d del Pezzo surface X and the geometry of curves of degree dr on X, and how it can be used to study the moduli of Ulrich bundles on X. This is joint work with Emre Coskun and Rajesh Kulkarni. (Received September 14, 2010)

1067-14-810 **Lubjana Beshaj*** (lbeshaj@univlora.edu.al), Lubjana Beshaj, 501, Godina C, Universiteti i Vlores, Vlora, Albania, and **Tanush Shaska** (shaska@oakland.edu), 546 Science and Engineering Bld., Department of Mathematics and Statistics, Oakland University, Rochester, MI 483094485. *The arithmetic of genus two curves.*

Genus 2 curves have been an object of much mathematical interest since eighteenth century and continued interest to date. They have become an important tool in many algorithms in cryptographic applications, such as factoring large numbers, hyperelliptic curve cryptography, etc. Choosing genus 2 curves suitable for such applications is an important step of such algorithms. In existing algorithms often such curves are chosen using equations of moduli spaces of curves with decomposable Jacobians or Humbert surfaces.

In this lecture we will discuss some new developments in the arithmetic of genus two curves and possible further applications. (Received September 15, 2010)

1067-14-819 **Christine Berkesch*** (cberkesc@math.su.se), Department of Mathematics, Stockholm University, SE-106 91 Stockholm, Sweden, and **Laura Felicia Matusevich**. *Equivariant methods for hypergeometric systems.*

The solutions of classical Horn systems of differential equations, including the Gauss and Appell–Lauricella hypergeometric equations, are among the most studied functions in mathematics. After applying a change of variables that gives an isomorphism of solution spaces, Horn systems are transformed into torus-equivariant systems, and the combinatorial tools of toric geometry have provided descriptions of important D-module theoretic properties of these new systems. While this change of variables does not induce an isomorphism at the level of differential equations, we establish a quotient relationship between Horn systems and their equivariant counterparts that opens the door for passage of these D-module theoretic properties to the classical setting. (Received September 15, 2010)

1067-14-831 **Leonardo C. Mihalcea*** (Leonardo_Mihalcea@baylor.edu), University of Louisiana at Lafayette, Dept. Of Mathematics, 440 Maxim Doucet Hall, Lafayette, LA 70504, and **Anders S. Buch**. *Spaces of rational curves in flag manifolds and the quantum Chevalley formula.* Preliminary report.

Given Ω a Schubert variety in a flag manifold, one can consider two spaces: the moduli space $GW_d(\Omega)$ of rational curves of fixed degree d passing through Ω (a subvariety of the moduli space of stable maps), and the space $\Gamma_d(\Omega)$ obtained by taking the union of these curves (a subvariety of the flag manifold). I will show how some simple considerations about the geometry of these spaces leads to a new, natural, proof of the equivariant quantum Chevalley formula proved earlier by Fulton and Woodward and by the speaker. This is joint work with A. Buch. (Received September 15, 2010)

1067-14-848 **Harlan Kadish*** (hmkadish@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Counting Generating Invariants for the Action of a Semisimple Group.*

Although degree bounds for the generators of various invariant rings have been known for almost a century, little is said about the cardinality of minimal generating sets. Estimates of such would provide lower bounds for the asymptotic complexity of algorithms that compute invariants. For a semisimple group G, choose an irreducible representation of highest weight λ, and consider the irreducible representations of highest weight $n\lambda$. As n goes to infinity, we show that the cardinality of a minimal set of generating invariants grows faster than any polynomial in n. When SL_2 acts on the binary forms of degree n, we show that the minimal set grows faster than any polynomial in d, and we provide combinatorial evidence that the growth is likely sub-exponential. (Received September 15, 2010)

1067-14-873 **Izzet Coskun*** (coskun@math.uic.edu), University of Illinois at Chicago, 851 S Morgan St SEO 322, Chicago, IL 60607, and **Aaron Bertram** and **Daniele Arcara**. *The birational geometry of the Hilbert Scheme of points in the plane.*

In this talk, I will describe the birational geometry of the Hilbert scheme of points in the projective plane. After summarizing results about the ample cone, the effective cone and the stable base locus decomposition, I will describe models that occur while running the Minimal Model Program. These models can be interpreted in terms of moduli spaces of Bridgeland stable objects and can also be constructed via GIT using quiver representations. (Received September 15, 2010)

1067-14-875 **Thomas Nevins*** (nevins@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana, IL 61801, and **David Ben-Zvi**, Department of Mathematics, University of Texas-Austin, Austin, TX 78712. *Toda lattice hierarchy and noncommutative geometry.*

The 2D Toda lattice plays an important role in algebraic geometry and integrable systems. Special periodic solutions, analogs of the rational, trigonometric, and elliptic KP solitons, have been explored by Krichever, Novikov, Zabrodin, Treibich, and others. I will explain a noncommutative-geometric point of view on these periodic solutions. (Received September 15, 2010)

1067-14-984 **Skip Garibaldi*** (skip@mathcs.emory.edu), Dept of Math & CS, MSC W401, 400 Dowman Dr, Emory University, Atlanta, GA 30322, and **Kirill Zainoulline**, Ottawa, Canada. *The gamma filtration and codimension 3 cycles on projective homogeneous varieties.*

We bound the torsion in the second quotient of Grothendieck's γ filtration on $K_0(X)$, where X is a certain kind of projective homogeneous variety under a linear algebraic group G. As a consequence, we obtain bounds on the torsion in $CH^3(X)$ and obtain information about the torsion of the generalized Rost motive of X, for some varieties X. (Received September 17, 2010)

1067-14-987 **Jérôme Poineau*** (poineau@math.unistra.fr), IRMA, 7, rue René Descartes, 67084 Strasbourg, France. *Topology of Berkovich Spaces.*

In the late 80's, V. Berkovich came up with a new definition of analytic space over a non-Archimedean complete valued field. Let us mention that E. Hrushovski and F. Loeser have very recently found a model-theoretic version of it. Unlike the non-Archimedean valued fields they are built from, Berkovich spaces turn out to enjoy nice topological properties such as local compacity or local arcwise connectedness. More general tameness properties hold, for instance concerning the number of connected components of families of spaces. Such results have important consequences in the ramification theory of local fields with imperfect residue fields as defined by A. Abbes and T. Saito. (Received September 17, 2010)

1067-14-1003 **Alan Stapledon*** (astapldn@math.ubc.ca), The University of British Columbia, Room 121, 1984 Mathematics Road, Vancouver, BC V6T 1Z2, Canada. *The tropical motivic nearby fiber.*

We construct motivic invariants of a subvariety of an algebraic torus from its tropicalization and initial degenerations. More specifically, we introduce an invariant of a compactification of such a variety called the 'tropical motivic nearby fiber'. Under suitable conditions, this invariant specializes to the Hodge-Deligne polynomial of the limit mixed Hodge structure of a corresponding degeneration. We deduce a formula for the Euler characteristic of a general fiber of the degeneration. This is joint work with Eric Katz. (Received September 17, 2010)

1067-14-1075 **Sándor J Kovács*** (skovacs@uw.edu), University of Washington, Department of Mathematics, Box 354350, Padelford Hall C-138, Seattle, WA 98103. *DB pairs and vanishing theorems.*

The class of rational singularities is one of the most important classes of singularities. Their essence lies in the fact that their cohomological behavior is very similar to that of smooth points. Vanishing theorems can be easily extended to varieties with rational singularities. Establishing that a certain class of singularities is rational opens the door to using very powerful tools on varieties with those singularities.

Du Bois singularities are probably somewhat harder to appreciate at first, but they are equally important. Their main importance comes from two facts: They are not too far from rational singularities, that is, they share many of their properties, but the class of Du Bois singularities is more inclusive than that of rational singularities; log canonical singularities are Du Bois, but not necessarily rational. The class of Du Bois singularities is also more stable under degeneration.

Recently there has been an effort to extend the notion of rational singularities to pairs. There are at least two approaches; Schwede-Takagi and Kollár-Kovács.

In this talk I will report on recent work to extend the definition of Du Bois singularities to pairs in the spirit of the latter approach to rational pairs. (Received September 18, 2010)

1067-14-1103 **Linda Chen*** (lchen@swarthmore.edu), Department of Mathematics and Statistics, Swarthmore College, 500 College Avenue, Swarthmore, PA 19801. *The quantum equivariant cohomology of flag varieties.*

Let X be a partial flag variety parametrizing successive subspaces in a vector space. We give a Giambelli formula which expresses Schubert classes in the quantum equivariant cohomology of X in terms of specializations of double universal Schubert polynomials. We obtain the result by proving and using an equivariant moving lemma on hyperquot schemes. This is joint work with Dave Anderson. (Received September 18, 2010)

1067-14-1116 **Mounir Nisse*** (nisse@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843, and **Frank Sottile** (sottile@math.tamu.edu), Department of Mathematics Texas A&M University, College Station, TX 77843. *Complex and non-Archimedean Coamoebas.*

A complex amoeba (resp. coamoeba) is the image of a subvariety of a complex torus under the logarithmic (resp. argument) map. The behavior of amoebas at infinity is linked to the geometry of the Newton polytope, in the case of complex hypersurfaces. For amoebas of complex varieties of codimension greater than one, Bergman, Bieri, and Groves show a similar fact using the notion of logarithmic limit set. In this paper, we introduce a similar object, called the *phase limit set*, and we show a structure theorem for coamoebas of a complex algebraic varieties. More precisely, if V is an algebraic variety of dimension k in $(\mathbb{C}^*)^n$, with coamoeba $co\mathcal{A}$, and phase limit set $\mathcal{P}^\infty(V)$. Then the closure of $co\mathcal{A}$ in the universal covering of the real torus is equal to $co\mathcal{A} \cup \mathcal{P}^\infty(V)$.

Moreover, $\mathcal{P}^\infty(V)$ is the union of an arrangement $\mathcal{H}(V)$ of k-torus and the coamoebas of some complex algebraic varieties of dimension l with $l \leq k-1$. Also, we introduce the notion of non-archimedean coamoebas, and we describe their structure in terms of complex coamoebas. (Received September 19, 2010)

1067-14-1180 **Anton Leykin***, leykin@math.gatech.edu. *Toward Numerical Primary Decomposition.*

Finding the primary decomposition of an ideal in a polynomial ring is one of the fundamental tasks of computational commutative algebra. While stopping short of producing the generators of primary components, our method provides a way to describe these components via approximate numerical data. This hybrid approach involves symbolic procedures applied to exact input along with approximate computation whose core is based on numerical homotopy continuation.

The ingredients necessary for a practical implementation of our numerical primary decomposition algorithm are being developed in the software package NAG4M2 (NumericalAlgebraicGeometry for Macaulay2). (Received September 19, 2010)

1067-14-1182 **Jordan S Ellenberg*** (ellenber@math.wisc.edu), 480 Lincoln Drive, Madison, WI 53706, and **Christopher J Hall** and **Emmanuel Kowalski**. *Expander graphs, gonality, and Galois representations.*

We show that 1-parameter families of abelian varieties over a number field K have few fibers over bounded-degree extensions of K whose mod-p Galois representations have "unexpectedly small image." This generalizes known results about elliptic curves and answers a question of Masser. The truth of the result is not surprising, but the method of proof is (to us) – the theorem uses in a central way new results on expansion in Cayley graphs of linear groups over finite fields due to Helfgott, Gill, Pyber-Szabo, Breuillard-Green-Tao, Golsifedy-Varju, etc. (Received September 19, 2010)

1067-14-1189 **Roya Beheshti***, Washington University, Cupples I, Campus Box 1146, Saint Louis, MO 63130, and **Mohan Kumar**. *Spaces of rational curves on hypersurfaces.*

I will discuss some aspects of the geometry of spaces of rational curves on general Fano hypersurfaces, including dimension, irreducibility, and birational geometry. A part of this talk is based on joint work with Mohan Kumar. (Received September 19, 2010)

1067-14-1206 **Steffen S Marcus*** (ssmarcus@math.brown.edu), Department of Mathematics, Brown University, Box 1917, Providence, RI 02912, and **Renzo Cavalieri**. *Polynomial Families of Tautological Classes on $\mathcal{M}_{g,n}^{rt}$.*

In this talk I will report on joint work with Renzo Cavalieri. Natural tautological classes $P_g(\alpha;\beta)$ on $\mathcal{M}_{g,n}^{rt}$ are studied. They arise by pushing forward the virtual fundamental classes of spaces of relative stable maps to an unparameterized $\mathbb{P}^1$ with prescribed ramification over 0 and ∞ given by partitions $\alpha \vdash d$ and $\beta \vdash d$ respectively. A theorem of Vakil shows the $P_g(\alpha;\beta)$ to be polynomial in the parts of the partitions. This polynomial is computed explicitly in low genus and low total length $l(\alpha)+l(\beta)$. I will discuss these computations and our approach to a general algorithm for computing these classes. (Received September 20, 2010)

1067-14-1220 **Izzet Coskun*** (coskun@math.uic.edu), 851 S Morgan Street SEO 322, Chicago, IL 60607, and **Jason Starr**. *Rational curves on cubic hypersurfaces.*

In this talk, I will prove that the space of rational curves of degree d on a smooth cubic hypersurface of dimension at least 3 is irreducible and of the expected dimension. I will also discuss the problem of irreducibility of spaces of rational curves in higher degree hypersurfaces. This is joint work with Jason Starr. (Received September 20, 2010)

1067-14-1227 **Artie Prendergast-Smith*** (prendergast-smith@math.uni-hannover.de), Institut für Algebraische Geometrie, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany. *The cone conjecture for Calabi–Yau pairs.*

The Morrison–Kawamata cone conjecture predicts the structure of the nef and movable cones of a variety, in various Calabi–Yau type situations. Roughly speaking, the conjecture says that these cones should enjoy a certain finiteness property relative to the action of the groups of automorphisms or birational automorphisms of the variety.

In this talk I will explain the predictions of the cone conjecture and discuss the cases in which it is known. In particular, I will mention some results of my own for threefolds with semiample anticanonical bundle. (Received September 20, 2010)

1067-14-1248 **Kiumars Kaveh*** (kaveh@pitt.edu), 301 Thackeray Hall, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *Newton-Okounkov bodies and crystal bases.*

Let G be a connected reductive algebraic group. We prove that the string parametrization of a crystal basis for a finite dimensional irreducible representation of G coincides with a natural valuation, on the field of rational functions on the flag variety G/B, constructed out of a coordinate system on a Bott-Samelson variety (or a flag of Schubert varieties on G/B). This shows that the string polytopes associated to irreducible representations, can be realized as Newton-Okounkov bodies for the flag variety. This fully generalizes an earlier result of A. Okounkov for Gelfand-Cetlin polytopes of symplectic group. As another corollary we deduce a multiplicativity property of the canonical basis due to Caldero. We generalize the results to spherical varieties. From these existence of SAGBI bases for homogeneous coordinate rings of flag and spherical varieties, as well as their toric degenerations follow (recovering toric degenerations of Alexeev-Brion, Caldero and the speaker). (Received September 20, 2010)

1067-14-1259 **Xiaoran Shi*** (xs4@rice.edu), Department of Mathematics, Management Research Building, East Campus, USTC, Hefei, Anhui 230026, **Xiaohong Jia** (xhjia@cs.hku.hk), Department of Computer Science, the University of Hongkong, Pokflam Road, and **Ron Goldman** (rng@cs.rice.edu), Department of Computer Science, 6100 South Main, Rice University, Houston, TX 77251-1892. *Genus of rational space curves indicated by μ-bases.*

We provide a new technique to detect the singularities of rational space curves. Given a rational parametrization of a space curve, we first compute a μ-basis for the parametrization. From this μ-basis we generate three planar algebraic curves whose intersection points correspond to the parameters of the singularities. A new sparse resultant matrix for these three polynomials is constructed. The parameter values corresponding to the singularities are computed by applying Gaussian Elimination to this sparse resultant matrix. We will use our methods to generalize some classical results on rational planar curves to rational space curves, and we shall present several examples to illustrate our methods. (Received September 20, 2010)

1067-14-1276 **Jesse Kass*** (jkass@umich.edu), Department of Mathematics, University of Michigan, 530 Church Street, Ann Arbor, MI 48103, and **Sebastian Casalaina-Martin** (casa@math.colorado.edu) and **Filippo Viviani** (viviani@mat.uniroma3.it). *Local Structure of the Compactified Jacobian.*

The Jacobian variety of a non-singular curve is a basic tool in algebraic geometry, and a fundamental question is "how to extend this construction to singular curves?" Starting with work of Igusa in the 1950's, a great deal of effort has gone into answering this question. Today we have a detailed understanding of how to assign a degenerate Jacobian to a singular curve.

However, our understanding of the geometry of these schemes is less extensive. In my talk I discuss my work on the local geometry of the Caporaso-Pandharipande degenerate Jacobian. This description suggests some interesting combinatorial problems for future study.

This work is joint with Sebastian Casalaina-Martin and Filippo Viviani. (Received September 20, 2010)

1067-14-1289 **Alexander Woo*** (woo@stolaf.edu), 1520 Saint Olaf Avenue, Northfield, MN 55057, and **Henning Ulfarsson**. *Local complete intersection Schubert varieties.* Preliminary report.

We characterize Schubert varieties which are local complete intersections (lci) by pattern avoidance conditions. For the Schubert varieties which are local complete intersections, we give an explicit minimal set of equations cutting out their neighborhoods at the identity. Although the statement only requires ordinary pattern avoidance, showing the other Schubert varieties are not lci appears to require working with interval pattern avoidance. The Schubert varieties defined by inclusions, originally introduced by Reiner and Gasharov, turn out to be an important subclass. (Received September 20, 2010)

1067-14-1310 **Paolo Aluffi***, Math Dept, Florida State University, Tallahassee, FL 32306. *A new look at Verdier specialization.*

Let $X \subset V$ be a closed embedding, such that $V \smallsetminus X$ is nonsingular. In this situation we define a constructible function ψ on X, which agrees with the 'Verdier specialization' of the constant 1 if X is the central fiber of a 1-parameter family of varieties, with nonsingular general fiber. The function ψ encodes topological information about the complement $V \smallsetminus X$ near X; for example, the effect of singularities of X on the genus of nearby fibers if X is the central fiber of a family of curves. We discuss concrete methods for the computation of this specialization function, possibly including a Macaulay2 implementation of an algorithm computing ψ. (Received September 20, 2010)

1067-14-1453 **Christopher Athorne*** (ca@maths.gla.ac.uk), Department of Mathematics, University Gardens, Glasgow, G14 9LZ, Scotland. *Identities for $\wp$-functions.*

We discuss relations between $\wp$-functions defined on Jacobian varieties associated with plane algebraic curves of genus g. These relations generalise the Weierstrass equation on the non-singular cubic: $\wp'^2 = 4\wp^3 - g_2\wp - g_3$. Generalised relations for certain classes of curves up to genus 6 have been obtained in the literature using the classical approach of balancing singularities in the $\wp$-functions and their derivatives implemented with powerful symbolic computation.

A modification of this approach utilizes elementary representation theory to isolate certain highest-weight relations amongst $\wp$-functions from which the other relations can be derived [Athorne, C., J. Phys. A 41 (2008), no. 41]. The representations arise from continuous families of birational maps between curves which make the vector space of holomorphic differentials on the curve into a (generally reducible) $\mathfrak{sl}_2(\mathbb{C})$ module.

This approach is implemented for hyper-elliptic curves of genus 1,2 and 3.

The pay-offs of the representation theoretic approach are: the computational cost is greatly reduced; the relations are ordered in such a way that their structure is more transparent; the connection with the underlying geometry is preseved. (Received September 21, 2010)

1067-14-1472 **Brian Harbourne**, **Hal Schenck** and **Alexandra Seceleanu*** (asecele2@illinois.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Inverse systems, Gelfand-Tsetlin patterns and the weak Lefschetz property.*

We use the inverse system dictionary to connect ideals generated by powers of linear forms to ideals of fat points and show that failure of the weak Lefschetz property for ideals generated by powers of linear forms is connected to the geometry of the associated fat point scheme. Recent results of Sturmfels-Xu allow us to relate the weak Lefschetz property to Gelfand-Tsetlin patterns. (Received September 21, 2010)

1067-14-1501 **David E Anderson*** (dandersn@math.washington.edu), Seattle, WA 98102. *Newton-Okounkov bodies of Bott-Samelson varieties.*

A construction of Okounkov, recently developed and studied further by Kaveh-Khovanskii and Lazarsfeld-Mustata, associates a convex body to any projective variety. I will discuss these bodies for projective embeddings of the Bott-Samelson varieties, showing that they are polytopes and giving descriptions in terms of root data. The toric degenerations that result generalize known degenerations of flag varieties and Schubert varieties. (Received September 21, 2010)

1067-14-1558 **Saikat Biswas*** (sbiswas@math.fsu.edu), Department of Mathematics, Florida State University, Tallahassee, FL 32306-4510. *The Tate-Shafarevich Group, Flat Cohomology and Visibility.*

The Tate-Shafarevich group of an elliptic curve is an important invariant and its conjectural finiteness can be used to determine the rank of the elliptic curve. The second part of the Birch and Swinnerton-Dyer conjecture gives a conjectural value for the order of this group in terms of other computable invariants of the elliptic curve. When the conjecture predicts that the group is non-trivial, the theory of visibility, initiated by Cremona and Mazur, can often be used to prove the existence of non-trivial elements in the group. In our talk, we will interpret the Tate-Shafarevich group in terms of flat cohomology and use this interpretation to improve a result of Agashe-Stein that uses the idea of visibility to show the existence of non-trivial elements of the Tate-Shafarevich group. (Received September 22, 2010)

1067-14-1594 **Nicole Marie Lemire*** (nlemire@uwo.ca), Department of Mathematics, University of Western Ontario, London, Ontario N6A 5B7, Canada. *Four dimensional algebraic tori.* Preliminary report.

We investigate the stable rationality of four-dimensional algebraic tori and the associated equivariant birational linearisation problem. (Received September 21, 2010)

1067-14-1641 **Sean Rostami*** (srostami@math.umd.edu), 8717 63rd Ave., Berwyn Heights, MD 20740. *Kottwitz's nearby-cycles conjecture for local models associated to unitary groups.* Preliminary report.

The purpose of this paper is to prove that the function associated, via the so-called "sheaf-function dictionary", to the sheaf of nearby cycles on a certain local model (in the sense of Rapoport-Zink et al.) is essentially a Bernstein function (meaning an element of the Bernstein basis for the Iwahori-Hecke algebra). The local model is one for which the associated algebraic group is a unitary similitude group GU(d). The analogous theorem for the cases of GL(d) and GSp(2d) was done in the 2002 paper "Nearby cycles for local models of some Shimura varieties" by Haines and Ngô. The method used in the current paper is an adaptation of the method used in the 2002 paper, which was itself inspired by a conjecture of Kottwitz. (Received September 21, 2010)

1067-14-1656 **Gretchen L. Matthews** (gmatthe@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975, and **Justin D. Peachey*** (jpeache@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975. *On Weierstrass semigroups of m-tuples of places on function fields associated with linearized polynomials.*

Let q be a power of a prime and $\mathbb{F}_q$ denote the field with q elements. Given a function field $F/\mathbb{F}_q$ and places $P_1, \ldots, P_m$ of degree one, the Weierstrass semigroup $H(P_1, \ldots, P_m)$ is the set of $\mathbf{v} \in \mathbb{N}^m$ such that there exists a function $f \in F$ with poles only at the $P_1, \ldots, P_m$ and the pole order at P_i is v_i for all $1 \le i \le m$. For $m = 1$, its complement is the classically studied Weierstrass gap set.

In this talk we consider the function field $\mathbb{F}_{q^r}(x, y)/\mathbb{F}_{q^r}$ defined by

$$x^u = L(y),$$

where $u | \frac{q^r-1}{q-1}$ and $L(y) = \sum_{i=0}^{d} a_i y^{q^i}$ is a linearized polynomial with $a_0, a_d \neq 0$ and q^d distinct roots in $\mathbb{F}_{q^r}$. The Hermitian and norm-trace function fields are special cases of this function field. We determine the Weierstrass semigroup $H\left(P_\infty, P_{0b_2}, \ldots, P_{0b_m}\right)$ where $2 \le m \le q^d + 1$ and give several examples. (Received September 22, 2010)

1067-14-1698 **Allen Knutson*** (allenk@math.cornell.edu). *Degeneration of Frobenius splittings, and Kazhdan-Lusztig varieties.*

Let $f \in k[x_1, \ldots, x_n]$. Starting with its hypersurface $f = 0$ we can construct a whole stratification $\mathcal{Y}$ consisting of closed subvarieties $Y \in \mathcal{Y}$, by decomposing what we have found so far, intersecting (some of) the components, and repeating.

Theorem. Assume $\deg f = n$ and *init* $f = \prod_{i=1}^n x_i$.

- Each *init* Y is reduced, a Stanley-Reisner scheme $SR(\Delta_Y)$. Indeed, the same holds true for any union of $Y \in \mathcal{Y}$.
- There is a well-defined order-preserving surjection π_f : {faces of Δ^{n-1}} $\to \mathcal{Y}$, such that *init* $Y = SR(\overline{\pi_f^{-1}(Y)})$.
- Given a reduced word Q in a (possibly infinite) Weyl group W, there are natural coordinates on the (finite-dimensional) opposite Bruhat cell $X_\circ^{\prod Q}$ under which the Bruhat decomposition arises in the way described above, the poset $\mathcal{Y}$ is the Bruhat interval $[1, w]$, and the map π_f takes a subword of Q to its Demazure product.

Time permitting, I will describe a number of important stratifications arising in the way above, related to quiver cycles, Hilbert schemes of points in the plane, positroid varieties, and wonderful compactifications of groups. (Received September 21, 2010)

1067-14-1764 **Fabrizio Donzelli*** (fabrizio@math.sunysb.edu), Institute of Mathematical Sciences, Stony Brook University, Math Tower, Stony Brook, NY 11794. *Algebraic density property of Danilov-Gizatullin surfaces.* Preliminary report.

A Danilov-Gizatullin surface is an affine surface V which is the complement of an ample section S of a Hirzebruch surface. The remarkable theorem of Danilov and Gizatullin states that the isomorphism class of V depends only on V. We show that the Lie algebra generated by the complete algebraic vector fields on V coincides with the set of all algebraic vector fields (i.e.: V has the ALGEBRAIC DENSITY PROPERTY). The proof makes use of the Danilov-Gizatullin theorem to present V as an algebraic quotient of an affine threefold F by the action of an affine torus T. This presentation of V allows us to calculate a set of generators of the ring of the T-invariant regular functions of F (that generate the ring of regular functions on V), and to find some useful complete T-invariant vector fields on F (that descends to complete vector fields on V). With those functions and vector fields we perform some simple computations involving Lie brackets, in order to apply some technical principles that imply the desired result. (Received September 22, 2010)

1067-14-1786 **Allen J Stewart*** (allens@uoregon.edu) and **Vadim Vologodsky**. *Motivic integral of K3 surfaces over $\mathbb{C}((t))$.*

We show that the motivic integral of a K3 surface over $\mathbb{C}((t))$ with strictly semi-stable reduction can be expressed purely in terms of the associated limit Hodge structure and suggest a conjectural formula for the motivic integral of a maximally degenerated K3 surface over an arbitrary non-archimedean field. (Received September 21, 2010)

1067-14-1889 **Elizabeth A. Sell*** (esell@millersville.edu), Department of Mathematics, Millersville University, P.O. Box 1002, Millersville, PA 17551-0302. *Some splice quotient double points.*

The splice quotients are an interesting class of normal surface singularities with rational homology sphere links. In general, it can be difficult to determine whether or not a singularity is a splice quotient (an analytic condition). We consider splice quotient deformations of splice quotients of the form $z^2 = x^a + y^b$, and show that in general not all equisingular deformations are splice quotients. (Received September 22, 2010)

1067-14-1922 **Luke Oeding*** (lukeoeding@gmail.com), Dipartimento di Matematica "Ulisse Dini", Viale Morgagni, 67/a, 50134 Firenze, FI, Italy, and **Daniel J. Bates**, CO. *Towards a salmon conjecture.*

By using a result from the numerical algebraic geometry package Bertini we show that (with extremely high probability) a set of degree six and degree nine polynomials cut out the secant variety $\sigma_4(\mathbb{P}^2 \times \mathbb{P}^2 \times \mathbb{P}^3)$. This, combined with an argument provided by Lansberg and Manivel, implies set-theoretic defining equations in degrees 5, 6 and 9 for a much larger set of secant varieties, including $\sigma_4(\mathbb{P}^3 \times \mathbb{P}^3 \times \mathbb{P}^3)$ which is of particular interest in light of the salmon prize offered by E. Allman for the ideal-theoretic defining equations. (Received September 22, 2010)

1067-14-2105 **Benjamin J Wyser*** (bwyser@math.uga.edu), 30. *Equivariant Cohomology Class Formulas for K-Orbit Closures in the Flag Variety.* Preliminary report.

Let G be a simple complex algebraic group of classical type. Let K be a symmetric subgroup of G, i.e. the fixed points of an involution of G. The geometry of K-orbit closures on the flag variety G/B is related to the representation theory of a corresponding real form of the group G.

We describe ongoing work on finding formulas for the T-equivariant cohomology classes of these orbit closures in the various classical cases. (Here, T is a maximal torus of the group K.) In the case of a closed K-orbit, one can compute the restriction of the class to each T-fixed point of G/B, and then use this information to try to "guess" a formula. If a formula is guessed correctly, then the Equivariant Localization Theorem gives an easy proof of its correctness.

With formulas for the closed orbits in hand, one can obtain formulas for the remaining orbits by moving up the weak closure order applying (suitably scaled) "Demazure operators".

This problem is a generalization of the analogous problem for Schubert varieties. The latter problem turns out to be the universal case for finding cohomology class formulas for certain types of degeneracy loci. Time permitting, we will discuss possible connections between the K-orbit picture and degeneracy loci. (Received September 22, 2010)

1067-14-2112 **Fyodor Malikov*** (fmalikov@usc.edu), 3620 So.Vermont Ave, Math.Dept., USC, Los Angeles, CA 90089. *Drinfeld-Sokolov reduction and algebras of chiral differential operators.*

Upon reviewing the definition of Drinfeld-Sokolov as an algebraic version of Hamiltonian reduction, we will prove that sometimes it can be described as a right derived functor. Time permitting, we will demonstrate how this result can be used to compute the cohomology of some sheaves of affine Lie algebra modules over flag manifolds. (Received September 22, 2010)

1067-14-2129 **Michael A Burr*** (mburr1@fordham.edu), 441 East Fordham Road, Mathematics Department, Fordham University, Bronx, NY 10458, and **Sung Woo Choi**, **Ben Galehouse** and **Chee K Yap**. *Isotopic Approximations of Singular Algebraic Curves.*

In practical situations, numerical algorithms are frequently used because they are fast and easy to implement. When confronted with singular inputs, however, such algorithms usually either fail to terminate or make arbitrary decisions at user defined accuracy. Both situations should be avoided if we desire the output of an algorithm to be correct. In singular situations, it is sometimes possible to use symbolic algorithms to study the behavior for the singular input; these algorithms, however, are typically much slower than their numerical counterparts.

One such problem is the isotopic curve approximation problem: given a polynomial $f \in \mathbb{Z}[X,Y]$ and a region of interest B_0 in the real plane, find a polygonal approximation to the variety $V(f)$ restricted to B_0 which is both close to the variety and has the same topology as the variety.

In this talk, I will present one of the first purely numerical algorithms that solves the curve approximation problem, and, therefore, is guaranteed to be topologically correct even in the presence of singularities. Even though the algorithm itself is numerical, the correctness result requires techniques from classical algebraic geometry. (Received September 22, 2010)

1067-14-2189 **Sharon Elizabeth Hutton*** (sehutton@ncsu.edu), North Carolina State University, Mathematics Department, Box 8205, Raleigh, NC 27695, and **Erich L. Kaltofen** (kaltofen@ncsu.edu) and **Lihong Zhi** (lzhi@mmrc.iss.ac.cn). *Exact Sums-of-Squares Certificates in Numeric Algebraic Geometry.*

We consider the problem of finding the nearest polynomial/system with a constrained root. Our distance measure to the nearest polynomial/system is the weighted Euclidean, one, or infinity coefficient norm. Although much work has already been done on this problem, we offer a new proof using parameterized Lagrangian multipliers, which allows for linear equality and inequality constraints on the coefficients via Karush-Kuhn-Tucker conditions. We also discuss exact sums-of-squares certificates for a lower bound of the distance to the nearest polynomial/system. Some polynomials that cannot be written as a sum-of-squares, such as a modified Motzkin polynomial, have a positive distance to the nearest polynomial with a real root and a sums-of-squares certificate for a positive lower bound. These sums-of-squares certificates offer an alternative proof that a polynomial has no real root and a deformation analysis for Seidenberg's problem.

These results are part of my Ph.D. thesis and joint work with Erich L. Kaltofen and Lihong Zhi. (Received September 22, 2010)

1067-14-2190 **Judson P. Stryker*** (jay.stryker@gmail.com). *Positivity of Chern classes for Schubert varieties in low codimension.*

Few results are known on the positivity of Chern-Schwartz-MacPherson classes of singular varieties. Aluffi and Mihalcea conjectured that these classes are effective for Schubert varieties in Grassmannians, and B. Jones proved some cases of this conjecture. We examine this question by applying combinatorial methods to a formula by Aluffi and Mihalcea. This technique establishes positivity for some known cases very quickly, such as those considered by Jones, as well as establishing positivity for families of cases that were previously unknown. An unexpected connection between one family of cases and a steady state Fokker-Plank equation was also found. (Received September 22, 2010)

1067-14-2271 **Elisabetta Fortuna** (fortuna@dm.unipi.it), Largo B. Pontecorvo 5, 56127 Pisa, Italy, **Patrizia Gianni** (gianni@dm.unipi.it), Largo B. Pontecorvo 5, 56127 Pisa, Italy, and **Barry M Trager*** (bmt@us.ibm.com), 1101 Kitchawan Road, Yorktown Heights, NY 10598. *Ideals of curves given by points.*

Let C be an irreducible projective curve of degree d in $\mathbf{P}^n(\mathbf{K})$, where $\mathbf{K}$ is an algebraically closed field, and let I be the associated homogeneous prime ideal. We wish to compute generators for I, assuming we are given sufficiently many points on the curve C. In particular if I can be generated by polynomials of degree at most s and we are given $sd+1$ points on C, then we can find a set of generators for I. We will show that a minimal set of generators of I can be constructed in polynomial time.

Our constructions are completely independent of any notion of term ordering and this allows us the maximal freedom in performing our constructions in the most numerically stable way possible.

We also summarize some classical results on bounds for the degrees of generators of our ideal in terms of the degree and genus of the curve. This work is in response to a problem posed to us by Mika Seppala at the AMS meeting in Washington two years ago.
(Received September 22, 2010)

1067-14-2291 **Julianna Tymoczko*** (tymoczko@math.uiowa.edu), 14 MacLean Hall, Department of Mathematics, University of Iowa, Iowa City, IA 52242. *Permutation group representations and (equivariant) cohomology of Hessenberg varieties.*

The cohomology of the flag variety carries a natural permutation action that we can describe elegantly and explicitly using a combinatorial description of equivariant cohomology called GKM theory. Hessenberg varieties are a natural family of subvarieties of the flag variety which share some important structure with the flag variety, including in some cases an action of the full torus. We will show that the cohomology of the Hessenberg varieties carries one of the permutation actions of the full flag variety. Time permitting, we will also discuss some amazing combinatorial conjectures and properties about these representations. Much of this work is joint with others, including Robert MacPherson (IAS) and Nicholas Teff (U of Iowa). (Received September 22, 2010)

1067-14-2339 **Anders S Buch*** (asbuch@math.rutgers.edu), **Pierre-Emmanuel Chaput**, **Leonardo C Mihalcea** and **Nicolas Perrin**. *Finiteness of cominuscule quantum K-theory.* Preliminary report.

The quantum K-theory of a homogeneous space X is a deformation of the ordinary K-theory ring, where the structure constants are defined as polynomial expressions in K-theoretic Gromov-Witten invariants. In contrast to (ordinary) cohomological GW invariants, the K-theoretic invariants can be non-zero in arbitrarily high degrees.

As a consequence, there might be infinitely many non-zero terms in the product of two Schubert classes. When X is a Grassmannian of type A, a Pieri rule proved by Mihalcea and the speaker implies that all products are finite. I will speak about new work with Chaput, Mihalcea, and Perrin that shows that the quantum K-theory of X is finite when X is any cominuscule homogeneous space. (Received September 22, 2010)

15 ► Linear and multilinear algebra; matrix theory

1067-15-54 **William R Henderson*** (henderwr@dukes.jmu.edu), **Jeffrey M Wyman** (wymanjm@dukes.jmu.edu), **Carla D Martin** (martincd@jmu.edu) and **Misha E Kilmer** (misha.kilmer@tufts.edu). *Multilinear Algebra and Tensors.* Preliminary report.

Using a novel method of order preserving tensor multiplication, we have defined several operators for this definition of tensor multiplication. We have extended several matrix decompositions to tensors, and explored their applications in video compression as well as facial recognition. In this talk we will be discussing the implementation of the tensor multiplication for third order and higher cases, as well as the construction of the operators and decompositions. (Received July 01, 2010)

1067-15-120 **Robert Fraser*** (rgf11@cwru.edu), **Michael C Steward**, **Shahla Nasserasr** and **Charles Johnson**. *A Solution to the Inverse Eigenvalue Problem for 3-by-3 Totally Nonnegative Matrices of Class 2.*

A matrix is said to be totally nonnegative of class k if its minors of size no greater than k are all nonnegative. We present a solution to the inverse eigenvalue problem for 3-by-3 totally nonnegative matrices of class 2 (TN_2). In particular, we show that the list $\{\lambda_1, \lambda_2, \lambda_3\}$ is the spectrum of a 3-by-3 TN_2 matrix if and only if $\lambda_2^2 \leq \lambda_1\lambda_2 + \lambda_1\lambda_3 + \lambda_2\lambda_3$. (Received July 25, 2010)

1067-15-125 **John Myers*** (john.myers@mines.sdsmt.edu), 1932 Red Dale Dr., Rapid City, SD 57702. *Unitary Equivalence to Matrices with Constant Main Diagonal.* Preliminary report.

Two iterative algorithms are developed to transform a given matrix to a unitarily equivalent matrix with constant main diagonal: one if the matrix has elements in $\mathbb{R}$ and one for elements in $\mathbb{C}$. In both cases, the algorithm will converge in finitely many iterations if the dimension of the matrix is a power of 2. Neither algorithm is globally continuous and for $\mathbb{R}$ a characterization of points of discontinuity is given. For $\mathbb{C}$, computer experiments reveal suspected points of discontinuity. Then – despite the algorithms' failure to be globally continuous – it is shown that in special cases there exist paths of matrices along which the algorithm is continuous. The results of further computer experiments are given that indicate such paths may exist in more general cases as well. (Received July 26, 2010)

1067-15-126 **Sam L Scholze*** (scholzes@uwplatt.edu), 435 Gardner Hall, 1 University Plaza, Platteville, WI 53818, and **Ryan L Hotovy** (ryan.hotovy@gmail.com), 203 Avery Hall, University of Nebraska-Lincoln, Lincoln, NE 68588. *Unitary Equivalence of Vector Spaces over the Binary Field.* Preliminary report.

Vector spaces over the binary field $\mathbb{Z}_2$ share certain properties with familiar vector spaces over $\mathbb{R}$ such as the existence of bases for spaces. There are, however, many differences. For example, when equipped with the dot product, a vector space over $\mathbb{Z}_2$ becomes an indefinite inner product space where non-zero vectors may have zero length. We continue previous work on these spaces by investigating subspaces of $\mathbb{Z}_2^n$ and ask when two vector spaces are unitarily equivalent. In particular we consider embeddings of subspaces into $\mathbb{Z}_2^n$ for some n. An algorithm is given showing that every vector space over $\mathbb{Z}_2$ can be embedded in this manner. We also investigate the existence of both Parseval frames and dual frames for vector spaces over $\mathbb{Z}_2$ and their relation to the Grammian operator. Finally we show that, unlike vector spaces over $\mathbb{R}$, the existence of a dual frame pair does not necessarily imply the existence of a Parseval frame of the same length for a space. (Received July 26, 2010)

1067-15-155 **Audrey Margaret Hubbard*** (audrey.hubbard@avemaria.edu) and **Christian Matthew Woods** (cmw55@pitt.edu). *The Energy of Graphs.*

Let M be a matrix associated with a graph G on n vertices. Let $\sigma(M) = \{\mu_1, \mu_2, \cdots, \mu_n\}$ be the set of eigenvalues of M, and let $\bar{\mu} = Tr(M)/n$ be their average. The *M-energy* of graph G is defined as

$$E_M G = \sum_{i=1}^{n} |\mu_i - \bar{\mu}|$$

The energies of several matrices associated with a graph have been studied, in particular, the adjacency energy, Laplacian energy, distance energy, and, more recently, the normalized Laplacian energy. In this talk, we explain the relationship between the normalized Laplacian matrix and the Randić matrix of a graph. We also present some relations we have found concerning several types of energy. In particular, we will derive formulas and bounds for the effects of various graph operations on adjacency and normalized Laplacian energy. Among these are binary operations such as the join, Cartesian product, tensor product, strong product, lexicographic product, and corona of two regular graphs, as well as an operation we call the "shadow" of a graph. (Received July 28, 2010)

1067-15-182 **Dian Yang*** (yangd1989@gmail.com), CSU 4062, PO Box 8793, College of William and Mary, Williamsburg, VA 23186. *Solution Theory for Bilinear Systems of Equations.*

For $A_1, \ldots, A_m \in M_{p,q}(\mathbb{F})$ and $g \in \mathbb{F}^m$, any system of equations of the form $y^T A_i x = g_i$, $i = 1, \ldots, m$, with y varying over $\mathbb{F}^p$ and x varying over $\mathbb{F}^q$ is called bilinear. A solution theory for complete systems ($m = pq$) is given in [JL]. Given here is a general solution theory for bilinear system of equations. In particular we prove that the problem of solving a bilinear system is equivalent to finding rank one points of an affine matrix function. For this, we notice a relationship between bilinear systems and linear systems. We also study systems with certain left hand side matrices $\{A_i\}_{i=1}^m$ such that a solution exist no matter what right hand side g is. A criterion is given to distinguish such $\{A_i\}_{i=1}^m$.

[JL] C. R. Johnson and J. A. Link, *Solution theory for complete bilinear systems of equations*, Numerical Linear Algebra with Applications, **16** No.11-12 (2009), pages 929–934. (Received August 14, 2010)

1067-15-387 **Philip V Vu*** (pvv1@williams.edu) and **Matthew Coudron** (coudr003@umn.edu). *Spectral Analysis of Non-Hermitian Matrices.*

Motivated by work of Contedini-Embree-Trefethen and Goldsheid-Khoruzhenko, we investigate the spectral properties of certain classes of non-Hermitian matrices. We give parametrizations for curves in the plane that contain the spectrum of bi-diagonal matrices with periodic diagonal entries. In the case of period two, we find an asymptotic formula for the spacing between these eigenvalues.

We also study the pseudospectrum $\sigma_\varepsilon(A)$ of a general square matrix A. We generalize the Bauer–Fike Theorem and give lower and upper bounds to show that the asymptotic decay (as $\varepsilon \to 0$) of the diameter of $\sigma_\varepsilon(A)$ near the eigenvalue λ is of order $\varepsilon^{1/k}$, where k is the dimension of the largest Jordan block associated to λ. (Received September 01, 2010)

1067-15-472 **Sylvester David Eriksson-Bique** and **Mary Katherine Solbrig*** (solbrigm@reed.edu), 5015 SE Rural St., Portland, Portland, OR 97206, and **Michael Stefanelli**, **Sarah Warkentin**, **Ralph Abbey** and **Ilse Ipsen**. *A Monte Carlo Algorithm for Computing Dot Products with Application to Information Retrieval.*

Our work is focused on randomized algorithms for dot products of vectors that sample a subset of the vector elements and provide an approximation to the dot product based on these. We develop an importance sampling method for a randomized matrix multiplication algorithm by Drineas, Kannan and Mahoney, and derive probabilities that minimize the expected value (with regard to the distributions of the matrix elements) of the variance. We compare these optimized probabilities with uniform probabilities, and derive conditions under which the actual variance of the optimized probabilities is lower. Numerical experiments with query matching in information retrieval applications illustrate that the optimized probabilities produce more accurate matchings than the uniform probabilities, and that they can also be computed efficiently. (Received September 06, 2010)

1067-15-506 **Wasin So*** (so@math.sjsu.edu), Department of Mathematics, San Jose State University, San Jose, CA 95192, and **Changqing Xu**. *The cprank and rank of a completely positive matrix.* Preliminary report.

An $n \times n$ real matrix A is *completely positive* if $A = BB^T$ for some $n \times m$ entry-wise nonnegative matrix B. And the smallest m is called the *cprank* of A. The determination of *cprank* is nontrivial. Obviously, we have $rank(A) \leq cprank(A)$ for any completely positive matrix A. In this talk, we present examples of completely positive matrices A with the property $rank(A) = cprank(A)$, and discuss the problem of characterizing completely positive matrices whose *rank* and *cprank* are equal. (Received September 07, 2010)

1067-15-553 **Charles D. Wessell***, Mathematics Department, Box 8205, North Carolina State University, Raleigh, NC 27695-8205, and **Carl D. Meyer**, Mathematics Department, Box 8205, North Carolina State University, Raleigh, NC 27695-8205. *Applying Simon-Ando Theory to Data Clustering.*

Given a nearly completely decomposable matrix A, Herbert Simon and Albert Ando described the stages that A^t passes through as t increases. If we wish to cluster the elements of a n-element data set and S is an $n \times n$ symmetric matrix whose entries measure the similarity between elements of the data set, S can be converted into a doubly stochastic matrix A and Simon-Ando theory can aid us in clustering the data set. Development of the algorithm and results will be presented. (Received September 09, 2010)

1067-15-559 **Jason J Molitierno*** (molitiernoj@sacredheart.edu), Department of Mathematics, 5151 Park Avenue, Fairfield, CT 06825. *A Matrix Theory Approach to Planar Graphs.*

In graph theory, a graph can be represented in terms of a Laplacian matrix. In the Laplacian matrix, the diagonal entries are the degree of each vertex and the off-diagonal entries are -1 if the vertices are adjacent and zero otherwise. Laplacian matrices are positive semidefinite, hence zero is always the smallest eigenvalue. The second smallest eigenvalue of the Laplacian matrix is termed the algebraic connectivity of a graph. The algebraic connectivity is zero if and only if the graph is disconnected. Adding edges to an existing graph can never cause the algebraic connectivity to decrease. Hence connected graphs with a greater number of edges tend to have larger algebraic connectivites. Since planar graphs have relatively few edges, it follows that the algebraic connectivity of such graphs should be low. In this talk, I prove that the algebraic connectivity of planar graphs is bounded above by 4 and show for which graphs that this upper bound is achieved. (Received September 09, 2010)

1067-15-1303 **Darren D. Row*** (ddrow@iastate.edu). *Computation of zero forcing number for some families of graphs.* Preliminary report.

For a simple undirected graph with each vertex initially colored either black or white, apply the rule that if a black vertex is adjacent to exactly one white vertex then that white vertex changes color to black. The zero forcing number of a graph is the smallest number of vertices needed to be initially colored black so that repeated applications of the rule will result in all vertices being black. Mathematicians study this parameter for its connection to the minimum rank/maximum nullity problem while physicists use it in studying quantum systems control. Techniques for computing zero forcing number for some families of graphs will be presented. (Received September 20, 2010)

1067-15-1312 **Joshua N Cooper*** (cooper@math.sc.edu), 1523 Greene St., Department of Mathematics, LeConte College, USC, Columbia, SC 29208, and **Aaron M Dutle** (dutle@math.sc.edu). *Spectra of Hypergraphs.*

We present a systematic spectral theory of hypergraphs that closely parallels graph spectral theory. Classic work by Gel'fand-Kapranov-Zelevinsky and Canny, as well as more recent developments by Chang, Lim, Pearson, Qi, Zhang, and others has led to a rich understanding of "hyperdeterminants" of hypermatrices, a.k.a. multidimensional arrays. Hyperdeterminants share many properties with determinants, but the context of multilinear algebra is substantially more complicated than the linear algebra required to understand spectral graph theory (i.e., ordinary matrices). Nonetheless, it is possible to define eigenvalues of a tensor via its characteristic polynomial and variationally. We apply this notion to the "adjacency hypermatrix" of a uniform hypergraph, and prove a number of natural analogues of graph theoretic results. Computations are particularly cumbersome with hyperdeterminants, so we discuss software developed in Sage which can perform basic calculations on small hypergraphs. Open problems abound, and we present a few directions for further research.

Joint work with Aaron Dutle of the University of South Carolina. (Received September 20, 2010)

1067-15-1712 **Russell L Carden*** (rlc2@rice.edu), CAAM, Rice University, 6100 Main St. MS 134, Houston, TX 77005-1892, and **Mark Embree** and **Derek Hansen**. *Behavior of Ritz Values for Normal Matrices and Jordan Blocks.* Preliminary report.

The field of values of a matrix is the closed convex subset of the complex plane containing all Rayleigh quotients, a set useful for understanding stability of dynamical systems, matrix iterations, among other applications. For a Hermitian matrix the field of values is the line connecting the largest and smallest magnitude eigenvalues and the Ritz values, eigenvalues of any restriction, must interlace with the eigenvalues of the full matrix. No similar geometric criteria exists for the Ritz Values of non-Hermitian matrices and in general how Ritz values may distribute themselves throughout the field of values of a matrix is not understood. We show for two particular classes of matrices, normal matrices and Jordan blocks, that the Ritz Values must satisfy some geometric

constraints. We illustrate how these results may be useful in analyzing eigenvalue computations. As Ritz values are used in numerous iterative methods a better understanding of their behavior for nonsymmetric matrices could offer a means of further analysis. (Received September 21, 2010)

1067-15-1997 **Edward Eugene Rehkopf*** (eerehkopf@usi.edu), 1456 Brookside Dr, Evansville, IN 47714. *Combining Triple Diagonal Forms.*

Let R be a Euclidean domain with quotient field F of characteristic not equaling 2. Jacobi showed that every symmetric R-matrix is congruent over R to a matrix in triple diagonal form. Since it is generally not possible to fully diagonalize these matrices, it is of importance to gain as much control as possible of this triple diagonal form. Two different refinements have since been made to Jacobi's triple diagonal form. This talk discusses these separate refinements and the combining of them. (Received September 22, 2010)

1067-15-2040 **Mary Clair Thompson*** (mct0006@tigermail.auburn.edu), Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849-5310, and **Tin-Yau Tam** (tamtiny@auburn.edu), Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36830. *Determinants of sum of orbits under compact Lie group.*

We study the determinants on the sum of orbits of two elements in the Lie algebra of a compact connected subgroup in the unitary group. As an application, the extreme determinant expressions are obtained for the symplectic group. (Received September 22, 2010)

1067-15-2062 **Thomas Milligan*** (tmilligan1@uco.edu), 100 N. University Drive, Box 129, Edmond, OK 73034. *Euclidean Squared Distance Matrices.* Preliminary report.

Distance geometry deals with the configuration of n points in metric space. For points $x_1, \ldots, x_n$ in Euclidean space, then $(A)_{i,j} = ||x_i - x_j||^2)_{i,j}$ is the corresponding Euclidean Squared-Distance (ESD) matrix. Recent results involving ESD matrices will be presented, including some results involving the geometry of the convex cone of ESD matrices. (Received September 22, 2010)

1067-15-2209 **Brian D. Sutton*** (bsutton@rmc.edu), Randolph-Macon College, 204 Henry St., PO Box 5005, Ashland, VA 23005. *Numerical stability of an algorithm for the complete CS decomposition.*

The CS (cosine-sine) matrix decomposition is an analogue of the singular value decomposition for partitioned unitary matrices. It can be used to compute the principal angles between linear subspaces, to find canonical correlations between statistical variables, and to break a quantum computer program into quantum logic gates. Although the decomposition has been known to exist since 1977, an algorithm for computing the full, original form of the decomposition was only recently discovered by the speaker. This talk will relate recent results on numerical stability, including a reformulation of the algorithm that enables easier analysis and appears useful outside of the context of a numerical stability proof. (Received September 22, 2010)

16 ► Associative rings and algebras

1067-16-4 **M Susan Montgomery***, Dept of Mathematics, KAP 108, University of Southern California, 3620 S. Vermont Ave, Los Angeles, CA 90089-2532. *Orthogonal Representations: From Groups to Hopf Algebras.*

In recent years Hopf algebras have had applications in mathematical physics, in particular conformal field theory, and in other parts of mathematics, such as knot theory and operator algebras. In this talk we discuss some recent progress in the representation theory of Hopf algebras which extends classical work in group theory.

Frobenius and Schur showed in 1906 that one can decide whether or not a complex representation V of a finite group G is real by computing the value of $\nu(V) = \frac{1}{|G|}\sum_g \chi(g^2)$, where χ is the character of V.

ν(V), the indicator of V, takes only three values, 0, 1, or -1. The representation is real precisely when $\nu(V)$ = +1; equivalently V has a symmetric non-degenerate $\mathbb{C}$-bilinear G-invariant form. Thus the elements of G act as orthogonal transformations on V.

In the last decade, Frobenius-Schur indicators have been extended to finite dimensional Hopf algebras and beyond, such as to quasi-Hopf algebras and fusion categories; they are invariants of the monoidal (tensor) category of representations. Moreover there are applications of indicators to Hopf algebras whose statements do not use indicators, such as results about classification or about the exponent of the Hopf algebra. (Received September 14, 2010)

1067-16-137 **Christopher J Wilson*** (cjwilson@butler.edu), Dept. of Mathematics and Actuarial Science, Butler University, 4600 W. Sunset Ave, Indianapolis, IN 46208. *Weak crossed product orders over discrete valuation rings.* Preliminary report.

A *weak* crossed product algebra over a discrete valuation ring is one whose cocycle is allowed to take any nonzero value (i.e. nonunit cocycle values are permitted).

Let S be the integral closure of a DVR in a tamely ramified Galois extension of the field of fractions. We show how to compute the radical of a weak crossed product ΣSx_σ in the case that S is a DVR. We then give necessary and sufficient conditions for ΣSx_σ to be a hereditary order and derive some interesting corollaries. (Received July 27, 2010)

1067-16-372 **Jon F. Carlson*** (jfc@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30601. *Computations with basic algebras.* Preliminary report.

We give an overview of a package in MAGMA for computations over basic algebras. The emphasis will be on the motivation for and recent development of a program to compute isomorphisms of basic algebras. (Received August 29, 2010)

1067-16-422 **Miriam Cohen*** (mia@cs.bgu.ac.il), Department of mathematics, Ben Gurion University, 84105 Beer Sheva, Israel, and **Sara Westreich** (swestric@mail.biu.ac.il), Department of Management, Bar Ilan University, 52900 Ramat Gan, Israel. *Conjugacy classes for Hopf algebras.*

An important instance of structure constants exists for finite groups and the way their class sums multiply this is connected to the associated character table.

We shall discuss the meaning of these concepts from the point of view of Hopf algebras and their duals and thus give a generalization of conjugacy classes and class sums for semisimple Hopf algebras H having a commutative character ring (quasitriangular Hopf algebras have this property) and a formula for their associated structure constants. When H is also factorizable these constants turn out to equal the fusion rules up to rational scalar multiples.

We also show a connection between the conjugacy classes and the commutator subspace of H. This connection boils down to a known connection for finite group algebras. (Received September 02, 2010)

1067-16-429 **Leonid Krop*** (lkrop@depaul.edu), Department of Mathematical Sciences, DePaul University, 2320 N. Kenmore, Chicago, IL 60614, and **Yevgenia Kashina** (ykasina@depaul.edu), Department of Mathematical Sciences, DePaul University, 2320 N. Kenmore, Chicago, IL 60614. *Classification of isomorphism types of a class of abelian extensions, by Y. Kashina and L. Krop.*

We determine the isomorphism types in the class of Hopf algebra extensions of a cyclic group C_2 of order 2 by an arbitrary finite, elementary 2- group G. Put $\mathrm{Aut}_{C_2}(G)$ for the group of C_2- linear automorphisms of G. Our main result asserts existence of a bijection between the orbits of $\mathrm{Aut}_{C_2}(G)$ in the group of Hopf algebra extensions $\mathrm{Opext}(\mathrm{k}C_2, \mathrm{k}G)$ and the isomorphism types of algebras in our class. In the special case of commutative or cocommutative extensions H, assuming G has rank n, the number of isotypes is $n+1$ if H is cocommutative, and $\frac{3n+(-1)^n+2}{2}$ if H is commutative. (Received September 23, 2010)

1067-16-453 **Manizheh Nafari*** (manizheh@uta.edu), Department of Mathematics, University of Texas at Arlington, P.O. Box 19408, Arlington, TX 76019-0408, **Michaela Vancliff** (vancliff@uta.edu), Department of Mathematics, University of Texas at Arlington, P.O. Box 19408, Arlington, TX 76019-0408, and **Jun Zhang** (zhangjun19@gmail.com), Department of Mathematics, University of Texas at Arlington, P.O. Box 19408, Arlington, TX 76019-0408. *Constructing Quadratic Quantum $\mathbb{P}^2$s from Graded Skew Clifford Algebras.*

The focus of this talk is to show that every point variety found by M. Artin, J. Tate, and M. Van den Bergh, as well as some point varieties not listed in their work (i.e. a cuspidal cubic curve and a nodal cubic curve), can be constructed by using graded skew Clifford algebras, either directly or indirectly via Ore extensions.

This is the first part of joint work with Michaela Vancliff and Jun Zhang. (Received September 04, 2010)

1067-16-493 **Christopher R Policastro*** (cpoli@mit.edu), 450 Memorial Drive, Cambridge, MA 02139. *Category $\mathcal{O}$ for the Rational Cherednik Algebra of G_{12}.*

The rational Cherednik algebra of a complex reflection group W with reflection representation $\mathfrak{h}$ is defined as a deformation of the algebra $\mathbb{C}[W] \ltimes S(\mathfrak{h}^* \oplus \mathfrak{h})$ depending on certain complex parameters. In this paper, we describe the irreducible representations in category $\mathcal{O}$ of the rational Cherednik algebra associated to G_{12}, in the Shephard-Todd notation, for an arbitrary complex parameter. In particular, we determine semisimplicity conditions on the category, Grothendieck group expressions for irreducible modules, and the characters for each irreducible finite dimensional representation. The determination of the structure of $\mathcal{O}$ uses computational and algebraic methods that should be easily applicable to other two dimensional complex reflection groups in the case of equal parameters. (Received September 07, 2010)

1067-16-618 **Mihai D Staic*** (mstaic@depaul.edu), DePaul University, Chicago, IL 60614. *Secondary cohomology for Hopf algebras.*

For a commutative Hopf algebra A we introduce a new cohomology theory. This is connected with the work of Khalkhali and Rangipour on cyclic modules for Hopf Algebras. If one thinks about the usual cohomology of a Hopf Algebra as the cohomology corresponding to the first level of a "Postnikov tower", then this new cohomology theory deals with the second level (therefore the need for the Hopf algebra to be commutative). (Received September 11, 2010)

1067-16-793 **Samuel K Hsiao** and **Gizem Karaali*** (gizem.karaali@pomona.edu), Claremont, CA 91711. *On Multigraded combinatorial Hopf algebras.*

We develop a theory of multigraded combinatorial Hopf algebras modeled on the theory of graded combinatorial Hopf algebras developed by Aguiar, Bergeron, and Sottile (2006). In particular we introduce the notion of canonical k-odd and k-even subalgebras associated with any multigraded combinatorial Hopf algebra, extending simultaneously the work of Aguiar et al. and Ehrenborg. (Received September 14, 2010)

1067-16-839 **Markus Schmidmeier*** (markus@math.fau.edu), 777 Glades Road, Boca Raton, FL 33431. *Invariant subspaces of nilpotent operators.*

Our interest is in invariant subspaces of nilpotent linear operators, more precisely, we consider systems (V, T, U) where V is a finite dimensional vector space, $T : V \to V$ a linear operator acting nilpotently with nilpotency index bounded by some number n, and $U \subset V$ a subspace which is invariant under the action of T.

The problem of classifying systems up to isomorphy has been posed by Garrett Birkhoff in 1934 in the corresponding situation for subgroups of finite abelian groups. It is of finite type if $n \leq 5$, has tame infinite type for $n = 6$, and is considered infeasible for $n \geq 7$. An analysis of the borderline situation throws light on the class of all invariant subspaces. It turns out that with finitely many exceptions in each dimension, the indecomposable systems for $n = 6$ occur in families indexed by continuous and discrete parameters, but have a very regular structure.

Solutions to the algebraic Riccati equation

$$0 = XA + XBX + C + DX$$

occur in optimal control theory as the steady-state solutions for linear time-invariant systems. The systems of invariant subspaces mentioned above provide minimal families of solutions to the Algebraic Riccati Equation.

This talk is a report on joint work with Claus Michael Ringel. (Received September 15, 2010)

1067-16-891 **Akira Masuoka*** (akira@math.tsukuba.ac.jp), University of Tsukuba, Ibaraki 305-8571, Japan. *Hopf algebraic approach to Picard-Vessiot theory.* Preliminary report.

Galois theory for differential or difference equations is called Picard-Vessiot theory. M. Takeuchi [J. Algebra 122(1989), 489–509] proposed a sophisticated, Hopf algebraic approach to the Picard-Vessiot theory for differential equations. K. Amano and I [J. Algebra 285(2005), 743–767] extended Takeuchi's theory so that it can apply to difference or mixed equations as well; see also the recent expository paper by the three of us which is contained in Handbook of Algebra Vol.6, 2009, Elsevier/North Holland. I will explain a Hopf-Galois theoretic idea of our approach as well as relevant new results by myself and by others. (Received September 16, 2010)

1067-16-989 **Kenneth L Price*** (pricek@uwosh.edu), Mathematics Department, University of Wisconsin Oshkosh, 800 Algoma Boulevard, Oshkosh, WI 54901. *Good Gradings from Relations.* Preliminary report.

Balanced relations were defined by G. Abrams to extend the convolution product used in the construction of incidence rings. We study the generalized incidence rings and construct good semigroup gradings using homomorphisms on the relations with finite images. Many of our theorems are based on known results for other types of graded algebras.

We define stable relations, which form a class between balanced relations and preorders. Compressions are also introduced and in our main theorem we prove every finite stable relation is the compression of a preorder. Thus there is an injective homomorphism from a generalized incidence ring over a finite stable relation to a matrix ring. (Received September 17, 2010)

1067-16-1064 **Andrea Jedwab*** (jedwab@usc.edu), 3620 S Vermont Ave, KAP 464D, Los Angeles, CA 90089, and **Susan Montgomery** (smontgom@usc.edu). *A q-identity related to a comodule.*

We determine a set of identities that are equivalent to a certain algebra being a comodule over the Taft algebra. We then show that the algebra is in fact a comodule algebra by giving a direct combinatorial proof of the identities.

These identities involve the q-binomial coefficients, where q is a primitive nth root of unity and n^2 is the dimension of Taft algebra. (Received September 17, 2010)

1067-16-1068 **Padmini P Veerapen*** (pveerapen@uta.edu), 900 Greek Row Dr Apt 105, Arlington, TX 76013. *A Notion of Rank for Noncommutative Quadratic Forms.*

To every (commutative) quadratic form is associated a symmetric matrix, and one has the standard notions of rank and determinant function defined on the matrix, and, thus, on the quadratic form. In a recent paper by T. Cassidy & M. Vancliff, the notion of quadratic form is extended to the noncommutative setting. In this talk, we will see that a notion of rank (or determinant function) may be defined on such noncommutative quadratic forms. (Received September 17, 2010)

1067-16-1258 **Mitja Mastnak*** (mmastnak@cs.smu.ca), Department Of Math. and C.S., Saint Mary's University, 923 Robie Street, Halifax, NS B3H3C3, Canada. *Cocycle deformations, calculus, and extensions.*

If H is a Hopf algebra over a ground field k, then a multiplicative cocycle on H is a unital linear map $\sigma\colon H\otimes H\to k$ satisfying the identity

$$(\varepsilon\otimes\sigma)*(\sigma(\mathrm{id}\otimes\mathrm{m}))=(\sigma\otimes\varepsilon)*(\sigma(\mathrm{m}\otimes\mathrm{id}))$$

in the convolution algebra $\mathrm{Hom}_k(H\otimes H\otimes H,k)$. If σ is such a map, then one can construct the cocycle twist H_σ of H by conjugating the multiplication m in H by σ, that is, $\mathrm{m}_\sigma=\sigma*\mathrm{m}*\sigma^{-1}$

I will describe various methods for computing multiplicative cocyles. These include exponential and q-exponential maps as well as cleft Hopf algebra extensions. Applications to the Andruskiewitsch-Schneider classification of pointed Hopf algebras will be considered. The talk is based on joint work with Luzius Grunenfelder. (Received September 20, 2010)

1067-16-1322 **Margaret Beattie*** (mbeattie@mta.ca), 67 York St, Sackville, NB E4L1E6, Canada. *Hopf algebras of small dimension.* Preliminary report.

Over an algebraically closed field, the problem of classifying all Hopf algebras of some given small dimension, such as 16 or 32, or for a class of dimensions, such as p, pq , pq^2, etc, for p,q prime, is a difficult one. General techniques are lacking and progress is slow. In recent years D. Fukuda has introduced some arguments involving dimensions and the coradical filtration that allowed him to complete the classification for dimensions 18 and 30. More recently, Cheng and Ng have worked on the problem of classifying Hopf algebras of dimension $4p$ and completed the classification for dimensions 20, 28 and 44. This talk will present some extensions of the techniques of Fukuda and some applications of these to the classification problem. This is joint work with G.A.Garcia. (Received September 20, 2010)

1067-16-1325 **Anne Quéguiner-Mathieu*** (queguin@math.univ-paris13.fr) and **Jean-Pierre Tignol**. *Triality and Arason invariant for algebras with involution.* Preliminary report.

Among Dynkin diagrams, the diagram of type D_4 is specific in that it admits automorphisms of order 3. The corresponding simply connected algebraic group is the cover $Spin_8$ of the special orthogonal group. Twisted forms of this group can also be viewed as the Spin group of some algebraic structure, namely an 8-dimensional quadratic form, or even, more generally, a degree-8 algebra with orthogonal involution. Because of triality, those degree-8 algebras with involution actually come by triple.

This fact can be used to understand invariants of degree-8 algebras with involution. By way of example, we will explain how to extend the Arason invariant of quadratic forms to involutions. If the underlying algebra is division, it is already known that there is no such invariant. Nevertheless, triality enable us to define a *relative* Arason invariant, which can be described as the Arason invariant of some quadratic form associated to any pair of orthogonal involutions. This invariant detects hyperbolic involutions. But, as opposed to what happens in quadratic form theory, it does not detect isomorphic involutions. In fact, it vanishes when the two involutions are isomorphic over any splitting field of the algebra, which does not imply they are isomorphic. (Received September 20, 2010)

1067-16-1381 **Greg Muller*** (gmuller@lsu.edu) and **Yuri Berest**. *Reflexive and Projective D-modules.* Preliminary report.

We study reflexive and projective D-modules over the ring of differential operators on a smooth algebraic variety. We describe such modules in terms of certain infinite-dimensional Grassmannians, extending the approach of Cannings-Holland from curves to higher dimensions. Our research is motivated, on the one side, by a known classification of right ideals in the first Weyl algebra and by interesting higher dimensional examples coming from representation theory and integrable systems. The bispectral problem has an appealing characterization in this language. We will review the results, give some new interesting examples, and discuss the application to the bispectral problem. (Received September 21, 2010)

1067-16-1485 **G. Alan Cannon**, **Lucyna Kabza**, **C. J. Maxson** and **Kent M. Neuerburg*** (kneuerburg@selu.edu), Dept of Mathematics, SLU Box 10687, Hammond, LA 70402. *Covered Groups and Simple Rings.*

For a group $(G,+)$ with identity 0, we let $C=\{A_1,\ldots,A_n\}$ be a cover by abelian subgroups. Further, let $R(C)=\{f : G\to G \,|\, f_{|A_i}\in End(G) \text{ for all } i=1,\ldots,n\}$. Under pointwise addition and function composition, $R(C)$ forms a ring. We will give conditions on G and C under which $R(C)$ will be a simple ring. (Received September 21, 2010)

1067-16-1743 **Christopher Goff*** (cgoff@pacific.edu), Department of Mathematics, 3601 Pacific Avenue, Stockton, CA 95211. *Fusion Rules for Abelian Extensions of Hopf Algebras.*

We investigate the representation theory of cocentral abelian extensions of Hopf algebras. In particular, we find central idempotents and use them to determine the fusion rules for such extensions. We then present a nontrivial example with noncommutative fusion rules, one which shows the abundance of such examples. (Received September 21, 2010)

1067-16-1815 **Andrew Conner***, Department of Mathematics, University of Oregon, Eugene, OR 97403. *The $\mathcal{K}_2$ Property for Face Rings.* Preliminary report.

A face ring is a factor algebra of a commutative polynomial algebra by a square-free monomial ideal whose generators correspond to non-faces of a simplicial complex Δ. Quadratic face rings are Koszul. $\mathcal{K}_2$ algebras are a natural generalization of Koszul algebras. We will describe topological conditions on Δ under which the associated face ring is $\mathcal{K}_2$. (Received September 21, 2010)

1067-16-1849 **David E. Radford*** (radford@uic.edu), Mathematics, Statistics, and Computer Sience, U. of Illinois at Chicago, 851 S. Morgan (m/c 249), Chicago, IL 69607-7045. *A Freeness Result Revisited.* Preliminary report.

The relationship between a Hopf algebra over a field and a Hopf subalgebra has been of interest over the years. Finite-dimensional Hopf algebras are free over their Hopf subalgebras by the Nichols-Zoeller Theorem. The first example of a Hopf algebra which is not free over one of its Hopf subalgebras was described by Oberst and Schneider; another example having the same characteristics was given by Takeuchi. These examples depend heavily on the field. An example defined over any field was described by the author. Generalizing the techniques used in the construction of the latter strongly suggests how to construct a class of commutative examples. Commutative Hopf algbebra are projective modules over their Hopf subalgebras by a result of Takeuchi. (Received September 22, 2010)

1067-16-1856 **Kelly McKinnie*** (kelly.mckinnie@umontana.edu), The University of Montana, Department of Mathematical Sciences, Mathematics Building, Missoula, MT 59812. *Degeneracy and Decomposability in Abelian Crossed Products.*

We discuss the connection between degeneracy and decomposability in abelian crossed products. In particular, a construction is given of a decomposable abelian crossed product defined by a non-degenerate matrix. This abelian crossed product has the property that it is in the Dec group with respect to one maximal subfield, but not with respect to another maximal subfield. (Received September 22, 2010)

1067-16-1876 **Marc Keilberg*** (keilberg@alumni.usc.edu), San Diego, CA 92117. *Indicators for the Drinfel'd doubles of certain groups.*

Frobenius-Schur indicators and their generalizations have proven to be a useful invariant of Hopf algebras, as well as other algebraic objects. For the group algebra of a finite group, these indicators are well-known to be integers. The same result is conjectured to hold for the Drinfel'd double of a finite group. However, little is known of connections between the structure theory of the group and the values of the indicators for its double.

We discuss several families of groups for which these indicators have been computed and the patterns that have emerged. (Received September 22, 2010)

1067-16-2020 **Christopher Lee Phan*** (clp020@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837. *Structural results for the Yoneda algebra of a connected-graded algebra.* Preliminary report.

Associated with every connected-graded algebra A is a bigraded algebra $E(A) = Ext_A(k,k)$, called the Yoneda algebra. The study of the connections between the structure of A and $E(A)$ is rich and includes topics such as the Koszul condition defined by Priddy and the $\mathcal{K}_2$ condition formulated by Cassidy and Shelton. We prove some additional results in this area, considering the case when A belongs to some classes of twisted tensor products or when A is a type of generalized Ore extension. (Received September 22, 2010)

1067-16-2184 **Yorck Sommerhaeuser*** (sommerh@jaguar1.usouthal.edu), University of South Alabama, Department of Mathematics and Statistics, 411 University Blvd N, Mobile, AL 36688. *The Central Charge of Factorizable Hopf Algebras coming from Bilinear Forms.* Preliminary report.

Recent work of Yongchang Zhu and the speaker established the following fact: For a semisimple factorizable Hopf algebra, the value of an integral on the Drinfel'd element and the value of this integral on the inverse Drinfel'd element differ only by a fourth root of unity. If the dimension is odd, they only differ by a sign, and this sign is a plus sign if the dimension is one modulo four, but a minus sign if the dimension is three modulo four.

The authors of this work conjecture that these two integral values always differ only by a sign, even if the dimension is not odd. In the talk, we provide some evidence for this conjecture by proving it for a class of factorizable Hopf algebras coming from bilinear forms. We also show that the conjecture is false for quasi-Hopf algebras, which can be constructed in an analogous way if one replaces bilinear forms with Eilenberg-MacLane cocycles. (Received September 22, 2010)

1067-16-2321 **Yiqiang Li*** (yqli@math.vt.edu), 460 McBryde Hall, Blacksburg, VA 24060. *On geometric realizations of quantum groups.*

A geometric construction of quantum groups by using localized equivariant derived categories of double framed representation varieties of a quiver will be presented. (Received September 22, 2010)

1067-16-2356 **Yevgenia Kashina*** (ykashina@depaul.edu) and **Leonid Krop**. *On classification of certain abelian extensions.* Preliminary report.

This talk is based on joint work with Leonid Krop on classification of isomorphism types of a class of abelian extensions. We consider an abelian extension of a group algebra of a cyclic group of order 2 by a group algebra of an elementary abelian 2-group. In this talk we will describe the concrete Hopf algebra structures of such abelian extensions. (Received September 22, 2010)

1067-16-2367 **Pinar Colak*** (ppekcagl@sfu.ca), Department of Mathematics, 8888 University Drive, Burnaby, BC V5A 1S6, Canada. *Two-sided ideals in Leavitt path algebras.*

Leavitt path algebras are a natural generalization of the Leavitt algebras, which are a class of algebras introduced by Leavitt in 1962. For a directed graph E, the Leavitt path algebra $L_K(E)$ of E with coefficients in K has received much recent attention both from algebraists and analysts over the last decade. So far, some of the algebraic properties of Leavitt path algebras have been investigated, including primitivity, simplicity and being Noetherian.

We explicitly describe the generators of two-sided ideals in Leavitt path algebras associated to arbitrary graphs. We show that any two-sided ideal I of a Leavitt path algebra associated to an arbitrary graph is generated by elements of the form $(v + \sum_{i=1}^{n} \lambda_i g^i)(v - \sum_{e \in S} ee^*)$, where g is a cycle based at vertex v, and S is a finite subset of $s^{-1}(v)$. (Received September 22, 2010)

17 ► Nonassociative rings and algebras

1067-17-212 **Earl J. Taft*** (etaft@math.rutgers.edu), Department of Mathematics, Rutgers University, Piscataway, NJ 08854, and **Zhifeng Hao** (mazfhao@scut.edu.cn), Department of Mathematical Science, South China University of Technology, Guangzhou, 510640. *The Lie product in the continuous Lie dual of the Witt algebra.*

Let k be a field of characteristic zero. The simple Lie algebra W_1=Der k[x], the one-sided Witt algebra, has a basis $e_i=x^{(i+1)}$d/dx for i at least -1). For each i, the wedge of e_0 and e_i satisfies the classical Yang-Baxter equation, giving W_1 the structure of a coboundary triangular Lie bialgebra $(W_1)^{(i)}$. The continuous Lie dual of $(W_1)^{(i)}$ is also a Lie bialgebra, and has been identified with the space of k-linearly recursive sequences by W. Nichols[J. Pure Appl. Alg. 68(1990), 359-364]. Let f=(f_n) and g=(g_n) be linearly recursive sequences in the continuous linear dual of $(W_1)^{(i)}$, [f,g] their Lie product. For each n, the n-th coordinate of [f,g] has been described in terms of the coordinates of f and of g[E. J. Taft, J. Pure Appl. Alg. 87(1993), 301-312], but it was an open problem to give a recursive relation satisfied by [f,g] in terms of recursive relations satisfied by f and by g. We give such a relation here. Analogous‘results hold for the two-sided Witt algebra W=Der k[x,$x^{(-1)}$]. (Received August 05, 2010)

1067-17-244 **Elizabeth Dan-Cohen*** (e.dancohen@jacobs-university.de), Campus Ring 1, 28759 Bremen, Germany, and **Ivan Penkov** and **Vera Serganova**. *Tensor category of integrable modules over $\mathfrak{sl}_\infty$, $\mathfrak{so}_\infty$, and $\mathfrak{sp}_\infty$.*

We find an interesting category of representations of the three simple finitary Lie algebras, $\mathfrak{sl}_\infty$, $\mathfrak{so}_\infty$, and $\mathfrak{sp}_\infty$. The modules in this category are not only integrable weight modules, but also together with their dual modules have finite Loewy length. We are able to describe the injective modules in this category, and show that the category corresponds to a particular Koszul ring. (Received August 12, 2010)

1067-17-452 **Irfan Bagci*** (irfan@math.ucr.edu), University of California at Riverside, Riverside, CA 92521. *On cohomology and support varieties for Lie superalgebras.*

In this paper we discuss finite generation of the relative cohomology rings for Lie superalgebras, we formulate a definition for detecting subalgebras,also discuss realizability of support varieties. As an application we compute the relative cohomology ring of the Lie superalgebra $\overline{S}(n)$ relative to the graded zero component $\overline{S}(n)_0$ and show that this ring is finitely generated. We also compute support varieties of all simple modules in the category of finite dimensional $\overline{S}(n)$-modules which are completely reducible over $\overline{S}(n)_0$. (Received September 04, 2010)

1067-17-454 **Toshihisa Kubo*** (toskubo@math.okstate.edu), 401 Mathematical Science, Oklahoma State University, Stillwater, OK 74078. *Conformally invariant systems of maximal parabolic of two-step nilpotent type.*

The wave operator $\square$ in Minkowski space $\mathbf{R}^{3,1}$ is a classical example of a conformally invariant differential operator. The Lie algebra $\mathfrak{so}(4,2)$ acts on $\mathbf{R}^{3,1}$ via a multiplier representation σ. When acting on sections of an appropriate bundle over $\mathbf{R}^{3,1}$,the elements of $\mathfrak{so}(4,2)$ are symmetries of the wave operator $\square$; that is, for $X \in \mathfrak{so}(4,2)$, we have

$$[\sigma(X), \square] = C(X)\square$$

with $C(X)$ a smooth function on $\mathbf{R}^{3,1}$.

The notion of conformal invariance of operators was generalized by Kostant in 1970's. Recently, Barchini, Kable, and Zierau introduce a notion of conformal invariance for systems of differential operators. In this talk we construct conformally invariant systems on a two-step nilpotent parabolic setting. We also show that these systems yield explicit $\mathcal{U}(\mathfrak{g})$-homomorphisms between certain generalized Verma modules. (Received September 04, 2010)

1067-17-899 **Rebecca L. Jayne*** (rljayne@ncsu.edu), North Carolina State University, Department of Mathematics, Box 8205, Raleigh, NC 27695. *On maximal weights of integrable $\widehat{sl}(n,\mathbb{C})$-modules.* Preliminary report.

For $\lambda = k\Lambda_0$, let $V(\lambda)$ be the integrable highest weight $\widehat{sl}(n,\mathbb{C})$-module. A dominant weight μ of $V(\lambda)$ is maximal if $\mu + \delta$ is not a weight. It is known that the set of maximal dominant weights of $V(\lambda)$ is finite. For $k \geq 1$, we give explicit descriptions of these maximal dominant weights and conjecture that their multiplicities are given by certain avoiding permutations. In particular, we show that for $k = 2$, the multiplicities are in one-to-one correspondence with 321-avoiding permutations. (Received September 16, 2010)

1067-17-902 **Kristen L Stagg*** (klstagg@ncsu.edu), 2108 SAS Hall, Box 8205, Raleigh, NC 27695, and **Ernest L Stitzinger**. *Minimal Non-Elementary Lie Algebra.* Preliminary report.

It is known that minimal non-elementary finite groups must be nilpotent. The Lie algebra analog admits non-nilpotent examples. This talk will classify them for solvable Lie algebras over an algebraically closed field. (Received September 16, 2010)

1067-17-995 **Pamela A Richardson*** (richarpa@westminster.edu), Department of Mathematics & Computer Science, Westminster College, New Wilmington, PA 16142, and **Jennifer Bowen** (jbowen@wooster.edu), Department of Mathematics & Computer Science, Taylor Hall 307, The College of Wooster, Wooster, OH 44691. *Centroids of Jordan Superalgebras over Superscalars.* Preliminary report.

The simple Jordan superalgebras with semi-simple even part were classified over an algebraically closed field of characteristic not 2 by M. Racine and E. Zelmanov. Previous work has been done determining the centroids of these classes of superalgebras over certain fields and arbitrary rings of scalars. A natural extension is to consider these Jordan superalgebras over algebras of superscalars. We will discuss preliminary results on the centroids in this case. (Received September 17, 2010)

1067-17-1186 **Christopher Martin Drupieski*** (cdrup@math.uga.edu), Department of Mathematics, University of Georgia, Boyd Graduate Studies Research Center, Athens, GA 30602-7403. *Cohomology rings for quantized enveloping algebras.* Preliminary report.

Let $\mathfrak{g}$ be a simple complex Lie algebra, and let $U_q = U_q(\mathfrak{g})$ be the associated quantized enveloping algebra (quantum group). It is a well-known theorem, first observed in the context of Lie groups, that the homology and cohomology algebras for $\mathfrak{g}$ are exterior algebras over graded subspaces with odd gradation. Moreover, the algebras are dual via Poincaré duality. In recent years, a number of authors have studied the homological properties of noetherian Hopf algebras, and have shown, for example, that the homology and cohomology groups for U_q also satisfy Poincaré duality, but until now there have been no explicit calculations of the cohomology groups in question. In this talk I will discuss how cohomology for the quantum group U_q can be related to cohomology for the Lie algebra $\mathfrak{g}$ in order to obtain explicit results. I will also discuss how results for the mod p cohomology of $\mathfrak{g}$ can be used to obtain explicit results on the cohomology of quantum groups at a p-th root of unity. (Received September 19, 2010)

1067-17-1228 **Ben L Cox*** (coxbl@cofc.edu), 66 George St, Math Dept., College of Charleston, Charleston, 29424, **Xiangqian Guo** (guoxq@zzu.edu.cn), Math Dept., Zhengzhou University, 450001, Zhengzhou, Peoples Rep of China, **Rencai Lu** (rencail@amss.ac.cn), Department of Mathematics, Suzhou university, 215006, Peoples Rep of China, and **Kaiming Zhao** (kzhao@wlu.ca), Wilfrid Laurier University, Math Department, Waterloo, ON N2L 3C5, Canada. *N-point Virasoro algebras and their dense representations.*

In this talk we introduce and describe what we call the n-point Virasoro algebra which is a natural generalization of the classical Virasoro algebra and is the universal central extension of the multipoint genus zero Krichever-Novikov type algebra. We determine the necessary and sufficient conditions for such algebras to be isomorphic, their automorphisms, their derivation algebras, their universal central extensions, and some other properties. We also construct a large class of modules which we call dense modules, and determine the necessary and sufficient conditions for them to be irreducible. (Received September 20, 2010)

1067-17-1715 **Philippe Di Francesco** and **Rinat Kedem***, University of Illinois, Department of Mathematics, Urbana, IL 61821. *Discrete integrability in recursion relations for (q)-characters and fusion coefficients.* Preliminary report.

I will talk about some beautiful formulas which appear to be related: graded multiplicity formulas for fusion coefficients and their relation to (quantum) Q-systems which are (quantum) cluster algebras. (Received September 21, 2010)

1067-17-1722 **Angela M. Brown*** (ambrown@uta.edu), Department of Mathematics, University of Texas at Arlington, P.O. Box 19408, Arlington, TX 76019. *Automorphisms on Albert-like Semifield Planes.* Preliminary report.

A semifield is a non-associative division ring. In 1958 Albert defined the "twisted fields" which are semifields with elements in $\mathbb{GF}(p^n)$ where p is prime and with multiplication defined by

$$x \circ y = xy^{p^m} - cx^{p^m} y$$

where $1 \leq m < n, c \neq a^{p^m-1}$ for $a \in \mathbb{GF}(p^n)$. In 1961 Albert further defined the "generalized twisted fields" similarly with a new product

$$x \circ y = xy - cx^\alpha y^\beta$$

where $\alpha, \beta \in$ Aut $(\mathbb{GF}(p^n)), c \neq x^{\alpha-1}y^{\beta-1}$ and $x, y \in \mathbb{GF}(p^n)$. We are taking this a step further by defining a new product

$$x \circ y = xy + Ax^\alpha y^\beta + Bx^\beta y^\alpha$$

where $\alpha \neq 1, \beta \neq 1, \alpha \neq \beta$ are automorphisms of $\mathbb{GF}(p^n)$ with $p \geq 3, n \geq 4$ and $A, B \in \mathbb{GF}(p^n)$, which adds one more term to Albert's previous generalization.

These algebraic structures can then be used to coordinatize projective planes. In our work we are looking at the types of automorphisms we obtain on the projective planes coordinatized by semifields with this product. (Received September 21, 2010)

1067-17-1801 **Bojko Bakalov*** (bojko_bakalov@ncsu.edu) and **Todor Milanov**. *W-constraints for simple singularities.*

Gromov-Witten invariants are naturally organized in a generating function, which is a formal power series in infinitely many variables. In many cases this function is a highest-weight vector for the Virasoro algebra and at the same time is a solution of an integrable hierarchy of partial differential equations. Similar generating functions can be introduced for the Frobenius structures coming from singularities of hypersurfaces. The generating function of a simple singularity was shown recently to be a solution of the Kac-Wakimoto hierarchy. Our main result is that it is also a highest weight vector for the corresponding W-algebra. (Received September 21, 2010)

1067-17-1804 **Lindsey R Bosko*** (lrbosko@ncsu.edu), 4006 The Oaks Dr, Raleigh, NC 27606. *Nontrivial Schur Multipliers of Nilpotent Lie Algebras.*

Given a group, G, its Schur multiplier can be defined as the second element of a maximal defining pair, the second cohomolgy group $H^2(G, \mathbb{C}^*)$ with trivial action, or $\frac{F^2 \cap R}{[F,R]}$ where $1 \to R \to F \to G \to 1$ is a free presentation of G. It is known that a $p-$group with trivial Schur multiplier has restrictions placed on it. We consider the Schur multipliers of Lie algebras, whose definition is analogous to the Schur multiplier of a group. We show that if a finite dimensional nilpotent Lie algebra algebra has dimension greater than one, then its Schur multiplier is non-zero. This is joint work with Dr. Ernest L. Stitzinger. (Received September 22, 2010)

1067-17-1808 **Jonathan D Dunbar*** (jddunbar@ncsu.edu), North Carolina State University, SAS Hall 2108, Campus Box 8205, Raleigh, NC 27695. *On Wakimoto representations of $\hat{sl}_2$ and* ***Z****-algebras.* Preliminary report.

We will discuss the Wakimoto representation of the affine Lie algebra $\hat{sl}_2$ at the critical level. Then, we study the representation of the associated Lepowsky-Wilson **Z**-algebras. This is joint work with Dr. Naihuan Jing and Dr. Kailash Misra. (Received September 22, 2010)

1067-17-1865 **Ivan Dimitrov*** (dimitrov@mast.queensu.ca), Department of Mathematics and Statistics, Queen's University, Kingston, Ontario K7L 3N6, Canada, and **Milen Yakimov** (yakimov@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918. *Double Lie bialagebra structure on Lie superalgebras.*

One of the central results in the theory of Quantum Groups is the Belavin–Drinfeld classification of quasitriangular Lie bialgebra structures on complex simple Lie algebras obtained in the early 80's. In recent years several attempts were made to extend this classification to simple Lie superalgebras but none was successful, even in the case when one looks for quasitriangular structures on a complex simple Lie superalgebra which make it a Drinfeld double. In my talk I will discuss the solution of the latter problem for basic classical Lie superalgebras. Not surprisingly, several new phenomena arise in the superalgebra case compared to the classical one. I will illustrate these with examples. (Received September 22, 2010)

1067-17-2014 **Prasad Senesi*** (senesi@cua.edu), 620 Michigan Ave NE, Opus Hall 108, Washington, DC 20064, **Erhard Neher** (senesi@cua.edu), Washington, 20064, and **Alistair Savage** (senesi@cua.edu), Washington, 20064. *Irreducible finite-dimensional representations of equivariant map algebras.*

Let $\mathfrak{g}$ be a finite-dimensional simple Lie algebra and A an affine algebraic variety defined over an algebraically closed field of characteristic 0. Let G be a finite group which acts via automorphisms upon $\mathfrak{g}$ and A. The Lie algebra of regular maps from A to g which are equivariant under the the action of G is called an equivariant map algebra. Examples of such algebras include current algebras, multiloop algebras (in particular, the untwisted loop algebras $\mathfrak{g} \otimes k\left[t^{\pm 1}\right]$ and their twisted subalgebras), and the Onsager algebras. In this talk we will classify the finite-dimensional irreducible representations of an arbitrary equivariant map algebra, and describe some conditions which ensure that all such representations are given by evaluation representations of $\mathfrak{g}$.

This is joint work with Erhard Neher and Alistair Savage. (Received September 22, 2010)

1067-17-2266 **Vitaly Tarasov*** (vt@math.iupui.edu), Department of Mathematical Sciences, IUPUI, 402 N. Blackford Street, Indianapolis, IN 46202-3216. *Bethe subalgebras of the group algebra of the symmetric group.*

I will introduce families of maximal commutative subalgebras, called Bethe subalgebras, of the group algebra $\mathbb{C}[S_n]$ of the symmetric group. The Bethe subalgebras depend on $n+1$ complex parameters $z_1, \dots z_n$, $\hbar$, and are deformations of the Gelfand-Zetlin subalgebra of $\mathbb{C}[S_n]$. The latter can be recovered from the Bethe subalgebras in the limit $z_a/z_{a+1} \to 0$ for all $a = 1, \dots, n-1$, and $\hbar/z_1 \to 0$.

The definition of Bethe subalgebras is motivated by the study of algebras of integrals of motion of quantum integrable models — the Gaudin model and the XXX-type spin chain, associated with the Lie algebra $\mathfrak{gl}_N$.

I will describe various properties of Bethe subalgebras including their geometric models as commutative algebras, and sets of generators which are counterparts of the Young-Jucys-Murphy elements in $\mathbb{C}[S_n]$. Surprisingly, relations for those generators of Bethe subalgebras involve the Baker-Akhiezer function on the Calogero-Moser space. (Received September 22, 2010)

18 ► Category theory; homological algebra

1067-18-228 **Emily Riehl*** (eriehl@math.uchicago.edu), Department of Mathematics, 5734 S University Ave, Chicago, IL 60637. *Algebraic model structures.*

In higher category theory, it is often productive to think of morphisms *algebraically*: equipped with some particular structure, rather than satisfying some defining property. Exploring this perspective in algebraic topology, we introduce *algebraic model structures*, which augment Quillen's model categories. Despite the plethora of familiar examples, this new theory has some peculiar features, which we describe. We also "algebraicize" classical results: for instance, defining an *algebraic Quillen adjunction* and proving they exist in common situations. (Received August 10, 2010)

1067-18-285 **Rosona M Eldred*** (reldred2@math.uiuc.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green St., Urbana, IL 61801. *Calculus of Functors.* Preliminary report.

Homology theories are one of the first tools we use to study spaces. They are also one of the first tools used in the study of functors from Spaces to Spaces (or Spectra); homology theories are linear functors. As we use linear *functions* to locally approximate more complicated functions, we can use linear *functors* to 'locally' approximate arbitrary functors. I will present the notion of linearity and derivative of a functor. These constructions (and their generalization to higher dimensions) are generally unwieldy; one goal of the field is to provide equivalent, but more tractable constructions. My work has provided several alternate and more intuitive constructions, which I will present for the linear case and suggest the higher dimensional case. (Received August 16, 2010)

1067-18-483 **Guerino Bruno Mazzola*** (mazzola@umn.edu), University of Minnesota, School of Music, 2106 Fourth Street South, Minneapolis, MN 55455. *Towards Gestural Music Analysis.*

We apply the mathematical theory of gestures as developed with Moreno Andreatta (published in the Journal of Mathematics and Music, Vol. 1, No.1 (2007), pp. 23-46 and in the same journal, Vol. 3, No. 1, (2009) pp. 31-58) to a gestural analysis of some modulations in Beethoven's Hammerklavier Sonata op.106. Technically speaking, this theory applies ideas from algebraic topology and their abstraction to topos theory. This approach adds to classical algebraically modeled harmony a new dimension of continuity that was evoked, but not realized, in David Lewin's transformational theory. (Received September 06, 2010)

1067-18-866 **Daniel Bravo*** (dbravovivall@wesleyan.edu), Mathematics and Computer Science Department, 265 Church St, Middletown, CT 06459. *An approach to the stable derived category via model categories.* Preliminary report.

Using the connection between cotorsion pairs and model categories, established by Hovey in 2002, we define, for any ring, a model category whose homotopy category is the stable derived category studied by Krause and others. This construction makes general properties of the stable derived category evident; for example it is a triangulated category and projective modules are trivial. In particular we provide a description of the stable derived category of $k[x,y]/(x^2, xy, y^2)$, where k is a field. (Received September 15, 2010)

1067-18-1455 **David A Jordan*** (djordan@math.mit.edu), Dept. of Mathematics, MIT, 77 Massachusetts Ave, Rm 2-236, Cambridge, MA 02130, and **Eric Larson**. *Fusion categories of dimension pq^2.*

In this talk, we completely classify integral fusion categories - and consequently, semisimple Hopf algebras - of dimension pq^2, where p and q are distinct primes. This is the simplest class of integer dimensions where non-group-theoretical categories arise; on the other hand, we prove that all semi-simple Hopf algebras of dimension pq^2 are group-theoretical. (Received September 21, 2010)

1067-18-1719 **Alin Stancu*** (stancu_alin1@colstate.edu), Department of Mathematics, Columbus State University, 4225 University Avenue, Columbus, GA 31907. *The Invariance and the General Cohomology Comparison Theorems.*

The *Invariance Theorem* of M. Gerstenhaber and S. D. Schack states that if $\mathbb{A}$ is a diagram of algebras then the subdivision functor induces a natural isomorphism between the Yoneda cohomologies of the category $\mathbb{A}$-**mod** and its subdivided category $\mathbb{A}'$-**mod**. In this paper we generalize this result and show that the subdivision functor is a full and faithful functor between two suitable derived categories of $\mathbb{A}$-**mod** and $\mathbb{A}'$-**mod**. This result combined with our work on the *Special Cohomology Comparison Theorem*, constitutes a generalization of M. Gerstenhaber and S. D. Schack's *General Cohomology Comparison Theorem*. (Received September 21, 2010)

19 ► K-theory

1067-19-185 **Paul Frank Baum*** (baum@math.psu.edu), Mathematics Department, University Park, PA 16802. *Expanders and K-theory for discrete groups.*

Let G be a locally compact Hausdorff second countable topological group. In particular, G can be any countable discrete group. The BC (Baum-Connes) conjecture proposes an answer to the problem of calculating the K-theory of the (reduced) C^* algebra of G. A very natural generalization of BC is BCC (Baum-Connes with coefficients). This talk will explain why a discrete group G which contains an expander in its Cayley graph is a counter-example to BCC. The reason is that in BCC, the proposed answer to the original K-theory problem "sees" any group G as if G were an exact group. A group which contains an expander in its Cayley graph is not exact, and is not even K-theoretically exact — and thus is a counter-example to BCC.

Of course this raises the question of whether or not a group containing an expander in its Cayley graph exists. M.Gromov indicated how such a group can be constructed. After several years of work by a number of mathematicians, the existence of such a group has now been proved. This group is known as the Gromov group.

BCC might be true for a group G iff G is exact. At the present time the only known examples of non-exact groups are the Gromov group and closely related groups constructed using the Gromov group. (Received July 29, 2010)

1067-19-257 **Paul Frank Baum*** (baum@math.psu.edu), Mathematics Department, Penn State University, University Park, PA 16802. *Dirac operator and K-theory for discrete groups.*

This talk will give the Dirac operator formulation of the BC (Baum-Connes) conjecture. This conjecture (when valid) has a number of corollaries. One of these is the Gromov- Lawson-Rosenberg conjecture which says that the only obstruction to a closed Spin manifold stably admitting a Riemannian metric of positive scalar curvature is the index of the Spin manifold's Dirac operator.

To state BC from the Dirac operator point of view, fix a (countable) discrete group G and consider pairs (M, E) where M is a Spin-c manifold without boundary with a given proper and co-compact action of G by diffeomorphisms which preserve the Spin-c structure of M. E is a G-equivariant complex vector bundle on M. On the collection of all such pairs (M, E) impose the equivalence relation generated by three elementary steps : (1) bordism (2) direct sum -disjoint union (3) vector bundle modification.This gives an abelian group which is the left side of BC.

The right side of BC is the K-theory of the reduced C* algebra of G. The map from the left to the right side sends a pair (M, E) to the index of the Dirac operaror of M twisted by E. BC asserts that this index map is an isomorphism. In particular, BC says that the index is a complete invariant for the above equivalence relation. (Received August 13, 2010)

1067-19-1288 **Seshendra Pallekonda*** (gosharma@gmail.com), 100 Parkway Blvd, Apt 36, Kingston, PA. *Lower Algebraic K-theory of virtually free groups.*

In this article, we describe the procedure to compute the lower K-groups of virtually free groups, using the facts that they satisfy Farrell-Jones isomorphism conjecture. (Received September 20, 2010)

20 ► Group theory and generalizations

1067-20-119 **James B Wilson*** (wilson@math.ohio-state.edu), Department of Mathematics, 231 West 18 Avenue, Columbus, OH 43210, and **Peter A Brooksbank** (pbrooksb@bucknell.edu), Department of Mathematics, Lewisburg, PA 17837. *Computing isometry groups of Hermitian maps.*

We prove a structure theorem for the isometry group of an Hermitian map $b : V \times V \to W$, where V and W are vector spaces over a finite field of odd order. We also present a Las Vegas polynomial-time algorithm to find generators for this isometry group, and to determine its structure. The algorithm can be adapted to construct the intersection of the members in a set of classical subgroups of $GL(V)$, yielding the first polynomial-time solution of this old problem. Our approach develops new computational tools for algebras with involution, which in turn have applications to other algorithmic problems of interest. An implementation of our algorithm in the MAGMA system demonstrates its practicability. (Received July 25, 2010)

1067-20-147 **Alexander Joerg Hulpke*** (hulpke@math.colostate.edu), Department of Mathematics, 1874 Campus Delivery, Fort Collins, CO 80523. *Computing Conjugacy Classes of Elements and Subgroups in Matrix Groups.*

Recent developments for matrix groups (the so-called Matrix Group Recognition Project) have developed algorithms to construct a composition series for a finite matrix group, given by generators. Using Conjugacy Classes of Elements and Subgroups as example, I want to show how one can build on these results to perform higher-level calculations in such groups: The key to generalizing existing algorithms is to construct a homomorphism $\varphi\colon G \to G/Rad(G)$ onto the radical factor of G, and to split generating sets for subgroups into a part in $\ker\varphi$, represented as a polycyclic group, as well as representatives with nontrivial images. (Received July 27, 2010)

1067-20-225 **Ellen M Ziliak*** (eziliak@ben.edu), 524 Truman Dr, Oswego, IL 60543, and **Alexander Hulpke**. *An Algorithm to Express Words as Conjugates of Relators.*

The goal of this talk will be to give a more efficient algorithm to rewrite a word in a finitely presented group as a product of conjugates of relators. This algorithm has a practical application for doing arithmetic in group extensions assuming the 2-cocycles are given. Current algorithms to do this rewriting use an augmeted coset table. Using an augmented coset table one quickly runs into difficulty in storing the table for large groups. This algoirthm will decrease the storage requirement by using properties of the Cayley Graph at run time. (Received August 09, 2010)

1067-20-256 **Catherine Andrea Buell*** (cabuell@ncsu.edu), 3021 Walnut Creek Pkwy Apt. L, Raleigh, NC 27606. *Conjugacy Classes of σ-stable Maximal k-split Tori.* Preliminary report.

Poster will describe topics requiring these conjugacy classes and methods used to determine them. The focus is on the real numbers and real symmetric spaces, commuting involutions, the Weyl group, and other elements used to determine the conjugacy classes. I will also discuss the fixed point groups of the involution σ and the associated conjugacy classes for further classification. (Received August 13, 2010)

1067-20-338 **Jane Gilman*** (gilman@rutgers.edu), Mathematics Department, Smith Hall, Rutgers University, Newark, NJ 07102, and **Linda Keen**. *Enumerating Primitives and Palindromes in Rank Two Free Groups.*

An element of a free group F of rank two is *primitive* if it, along with another group element, generates the group. If $F = \langle A, B\rangle$, then a word $W(A, B)$ in A and B, is a *palindrome* if it reads the same forwards and backwards. It is known that in a rank two free group, for any fixed set of two generators a primitive element will be conjugate either to a palindrome or to the product of two palindromes, but known iteration schemes for all primitive words give only a representative for the conjugacy class. We derive a new iteration scheme that gives either the unique palindrome in the conjugacy class or expresses the word as a unique product of two unique palindromes that have already appeared in the scheme. We find necessary and sufficient conditions for any pair of words in the free group to be a primitive pair. The derivation of the enumeration scheme gives new proofs of known results about primitive words. (Received August 24, 2010)

1067-20-350 **Peter Loth*** (lothp@sacredheart.edu), Department of Mathematics, Sacred Heart University, Fairfield, CT 06825. *$\mathbb{Z}_p$-modules with partial decomposition bases.* Preliminary report.

Warfield modules are direct summands of simply presented $\mathbb{Z}_p$-modules or, alternatively, are $\mathbb{Z}_p$-modules possessing a nice decomposition basis with simply presented cokernel. The concept of decomposition basis was generalized to the notion of partial decomposition basis by Jacoby. In this paper, we discuss a model-theoretic classification of $\mathbb{Z}_p$-modules possessing a partial decomposition basis in the language $L^{\delta}_{\infty\omega}$. (Received August 25, 2010)

1067-20-370 **Jacek Brodzki**, **Graham A. Niblo** and **Piotr W. Nowak*** (pnowak@math.tamu.edu), Department of Mathematics, Texas A&M University, Mailstop 3368 TAMU, College Station, TX 77843, and **Nick J. Wright**. *On (co)homological characterizations of exact groups.*

Exactness (also known as Yu's property A) is a weak notion of amenability for groups with very strong applications such as the Novikov conjecture. Nigel Higson asked if exactness can be characterized via homology or cohomology, similarly as amenability. In this talk we will give an answer to Higson's question by characterizing exact groups in terms of bounded cohomology and in terms of uniformly finite homology. Both of these characterization are vast generalizations of classical results due to B.E.Johnson and Block-Weinberger respectively. (Received August 29, 2010)

1067-20-373 **Philip Keen***, School of Mathematics, University of Birmingham, Edgbaston, Birmingham, B15 2TT, England. *An Investigation into an Amalgam between an $SU_3(q)$ and an $SL_3(q)$: Preliminary Report.* Preliminary report.

Following the success of Phan's Theorem and the Curtis-Tits Theorem in describing amalgams of unitary groups and amalgams of linear groups, respectively, I attempted to investigate an amalgam between an $SL_3(q)$ and an $SU_3(q)$, amalgamated in an $SL_2(q)$. The amalgam I investigated collapsed. In this paper, I describe the reason for its collapse. I then go on to investigate the wider consequences for larger amalgams of unitary and linear groups. (Received August 30, 2010)

1067-20-389 **E. Breuillard**, **B. Green**, **R. Guralnick*** (guralnic@usc.edu) and **T. Tao**. *Expansion and words in simple groups of Lie type.*

We will discuss generation properties of a pair of words in the finite simple groups of Lie type. This is related to results about random pairs of elements giving rise to expanders in the finite simple groups of Lie type (Received August 31, 2010)

1067-20-425 **Yakov I Berchenko-Kogan*** (yashabk@caltech.edu), MSC 134 Caltech, 1200 E California Blvd, Pasadena, CA 91126. *Distance in the Ellipticity Graph.*

I. Kapovich and M. Lustig defined a curve complex analogue for free groups called the ellipticity graph, whose vertices are cyclic words and free splittings of the group. I present an algorithm that uses Stallings subgroup X-digraphs and Whitehead automorphisms to determine when the distance between two vertices of the ellipticity graph is two. In addition, I obtain a bound on the distance using Nielsen transformations. (Received September 02, 2010)

1067-20-462 **Juan Gonzalez-Meneses*** (meneses@us.es), Dept. Algebra., Facultad de Matematicas. Univ. de Sevilla., Apdo. 1160., 41080 Sevilla, Spain. *Generating random braids.*

In most papers in computational braid theory and braid cryptography, the method for generating braids of a given length consists of generating random words in the given generators. This is not satisfactory as it does not yield a uniform distribution, hence braids are not generated with identical probability. We will explain an efficient method to generate random positive braids. As a by-product, we will obtain a new and more efficient method for counting the number of positive braids of a given length. (Received September 05, 2010)

1067-20-477 **Thomas Q. Sibley*** (tsibley@csbsju.edu), Mathematics Department, St. John's University, Collegeville, MN 56321-3000. *Groups of Graphs of Groups.*

We explore a graphical representation of groups differing from Cayley digraphs. While the automorphism group of a Cayley digraph is always isomorphic to the original group, the edge colored graphs we discuss can have larger groups of automorphisms. In addition, these graphs generalize to a family of loops with interesting properties, including Lagrange's Theorem and the Sylow Theorems. We discuss known results and open questions for these graphs and their groups. (Received September 06, 2010)

1067-20-526 **Mark F Hagen*** (markfhagen@gmail.com), Burnside 1019, Dept. of Math. and Stat., McGill University, 845 Sherbrooke St. West, Montreal, Quebec H3A 2K6, Canada. *Groups with a quasiconvex hierarchy.*

I will discuss recent work of Dani Wise on groups having a quasiconvex hierarchy. I shall define the notion of a special cube complex and give an outline of the proof of Wise's result, that word-hyperbolic groups with quasiconvex hierarchies virtually embed in right-angled Artin groups. (Received September 08, 2010)

1067-20-563 **Eduardo Martínez-Pedroza*** (emartinez@math.mcmaster.ca) and **Daniel T. Wise** (daniel.wise@mcgill.ca). *Local Quasiconvexity of Groups acting on Small Cancellation Complexes.*

Given a group acting cellularly and cocompactly on a simply-connected 2-complex, we provide a criterion establishing that all finitely generated subgroups have quasiconvex orbits. This work generalizes the "perimeter method" of McCammond and Wise. As an application, we show that high-powered one-relator products $A * B/\langle\langle r^n \rangle\rangle$ are coherent if A and B are coherent. (Received September 09, 2010)

1067-20-698 **Christopher H. Cashen*** (cashen@math.utah.edu), University of Utah, Department of Mathematics, 155 S 1400 E RM 233, Salt Lake City, UT 84112. *Line Patterns in Free Groups.*

Let w be a non-trivial word in a finite rank free group F. The w–line through $g \in F$ is the coarse equivalence class of the set $\{gw^m\}_{m\in\mathbb{Z}}$. The line pattern generated by w is the collection of distinct w–lines.

There is topological space, the quotient of the boundary at infinity of F obtained by identifying the two endpoints of a line in the pattern, that encodes the large scale geometry of the line pattern. A quasi-isometry of F that coarsely preserves the line pattern gives a homeomorphism of this topological space, and by studying the finite cut set structure we obtain rigidity results for pattern preserving quasi-isometries and a JSJ-decomposition for F relative to the line pattern.

Applications include quasi-isometry classifications for some classes of graphs of free groups and a characterization of virtually geometric multiwords. (Received September 13, 2010)

1067-20-841 **Josh Wiscons*** (wiscons@colorado.edu), Department of Mathematics, University of Colorado, UCB 395, Boulder, CO 80309. *Groups of finite Morley rank with a split BN-pair of rank 1.*

We present a result that identifies certain 2-transitive permutation groups of finite Morley rank as $\mathrm{PSL}_2(K)$ for K an algebraically closed field. We cast the result in the language of BN-pairs and show how it fits into addressing the Cherlin-Zil'ber conjecture: every infinite simple group of finite Morley rank is an algebraic group over an algebraically closed field. (Received September 15, 2010)

1067-20-844 **Emmanuel F Breuillard*** (breuilla@math.u-psud.fr), Laboratoire de Mathematiques, Universite Paris Sud, 91405 Orsay, France. *On the diameter of finite simple groups.*

I will discuss worst case upper bounds on the diameter of finite simple groups. In the special case when the rank of the groups are bounded, techniques from recent works of Pyber-Szabo, Breuillard-Green-Tao, Breuillard-Green-Guralnick-Tao and Breuillard-Gamburd can be applied to study this question. (Received September 15, 2010)

1067-20-943 **Marek Zabka*** (zabka@fphil.uniba.sk), Department of Musicology, Comenius University, 81801 Bratislava, Slovak Rep. *Fokker's 'Periodicity Blocks', Hellegouarch's 'Natural Scales', and my 'Generated Tone Systems'.*

Many common tone systems can be modeled using lattices generated by two or more base elements. Special subsets or special quotient groups of such lattices yield convincing formalization of various musical scales. The three formal constructs mentioned in the title strive to build theoretical framework of this kind. Although they share the core idea the relations between the three concepts are manifold and their investigation involve non-trivial mathematical exploration. The paper addresses this issue, reformulates the three approaches within a single terminology and presents preliminary mathematical results. (Received September 16, 2010)

1067-20-983 **Skip Garibaldi*** (skip@mathcs.emory.edu), Dept of Math & CS, MSC W401, 400 Dowman Dr., Emory University, Atlanta, GA 30322. *The image of a root system in a Coxeter plane.*

The picture of E8 that appears in newspapers and magazines (popularized by the Atlas group) is the projection of the E8 root system in a Coxeter plane. We prove that the radii of the circles – sometimes called "Gosset circles" – in the picture are the entries in a Perron-Frobenius eigenvector for the Cartan matrix. The theorem is known, but by a roundabout proof; we give a very simple proof within the language of root systems. We apply the theorem to compute the radii. The motivation for all of this is that the ratio of the two largest radii in the E8 case has a physical interpretation which has recently been observed in the laboratory. (Received September 17, 2010)

1067-20-993 **Sean Cleary**, Department of Mathematics, The City College of New York, City University of New York, New York, NY 10031, **Susan Hermiller*** (smh@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130, **Melanie Stein**, Department of Mathematics, Trinity College, Hartford, CT 06106, and **Jennifer Taback**, Department of Mathematics, Bowdoin College, Brunswick, ME 04011. *Geometric properties of Thompson's group F.*

The isodiametric function can be thought of as measuring the height of the tallest peak in a van Kampen diagram for a presentation; in this talk I will discuss a refinement of this, namely a filling function that measures the overall "tameness" of the peaks and valleys in van Kampen diagrams. For Thompson's group F, I will discuss geometric properties of the Cayley 2-complex and a quasi-geodesic combing which lead to a proof that the tameness function is linear for this group. (Received September 17, 2010)

1067-20-994 **Matvei Libine*** (mlibine@indiana.edu). *Split Quaternionic Analysis and Representation Theory.*

This is a joint work with Igor Frenkel.

I will describe our new developments of quaternionic analysis using representation theory of various real forms of the conformal group. We show that the counterparts of Cauchy and Poisson formulas solve the problem of separation of the discrete and continuous series for SL(2,R) and the imaginary Lobachevski space SL(2,C)/SL(2,R). We also obtain a surprising formula for the Plancherel measure on SL(2,R) in terms of the Poisson integral on the split quaternions.

Along the way we discover another connection between quaternionic analysis and mathematical physics. We show that the massless singular functions of four-dimensional quantum field theory are nothing but the kernels of projectors onto the discrete and continuous series on the imaginary Lobachevski space.

The talk is based on a recent paper "Split Quaternionic Analysis and Separation of the Series for SL(2,R) and SL(2,C)/SL(2,R)" (submitted). (Received September 17, 2010)

1067-20-1040 **Thomas Noll*** (noll@cs.tu-berlin.de), Pfarrstr. 6, 04860 Torgau, Germany. *Well-formed Scales and Alteration: An Arithmetic Investigation into Music Notation.*

The paper elaborates upon theoretical cross links between E. Regener's mathematical approach to musical notation, N. Carey and D. Clampitt's theory of well-formed scales, E. Agmon's investigation into combined diatonic and chromatic tone relations, and J. Hooks theory of key signatures and enharmonic systems. It studies an extension of a linear automorphism of the cyclic group $\mathbb{Z}_m$ to an isomorphism between two group extensions of this group by the group of integers $\mathbb{Z}$. Music-theoretically, the isomorphism extends the generic level of a well-formed scale to a level of chromatic alteration. The middle arrow α in the diagram

$$\begin{array}{ccccccccccc} E_1: & 0 & \to & \mathbb{Z} & \to & \mathbb{Z}\times\{0,...,m-1\} & \to & \mathbb{Z}_m & \to & 0 \\ & & & \downarrow id & & \downarrow \alpha & & \downarrow \cdot n & & \\ E_{\overline{n}}: & 0 & \to & \mathbb{Z} & \to & \mathbb{Z}\times\{0,...,m-1\} & \to & \mathbb{Z}_m & \to & 0 \end{array}$$

controls the conversion from generation order to scalar order under the effect of chromatic alteration. The extension of the generic level by register behaves analogously. The combination of both extensions refines the concept of height-width duality from recent joint work with D. Clampitt. (Received September 22, 2010)

1067-20-1051 **Brent B. Solie*** (solie@math.uiuc.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green St., Urbana, IL 61801. *Genericity of Filling Elements.*

An element of a finitely generated non-Abelian free group $F(X)$ is said to be *filling* if that element has positive translation length in every very small minimal isometric action of $F(X)$ on an $\mathbb{R}$-tree. We give a proof that the set of filling elements of $F(X)$ is exponentially $F(X)$-generic in the sense of Arzhantseva and Ol'shanskiĭ. We also provide an algebraic sufficient condition for an element to be filling and show that there exists an exponentially $F(X)$-generic subset of filling elements whose membership problem is solvable in linear time. (Received September 17, 2010)

1067-20-1059 **Robert Peck*** (rpeck@lsu.edu) and **Jack Douthett** (douthett@comcast.net). *Wreath products and n-cube symmetry: a music-theoretical application.* Preliminary report.

In this presentation we explore the symmetry group (a wreath product) of the hypercube. We associate vertices of n-cubes with objects in musical spaces, and members of the symmety group with transformations on those spaces. Among other applications we develop a non-Riemannian approach for the Cohn hexatonic system using a subgroup of the 3-cube and Cohn's sum classes. This idea is then extended to seventh chords and French sixths in the 4-cube. (Received September 17, 2010)

1067-20-1095 **Alexei Miasnikov*** (amiasnikov@gmail.com), Department of Mathematics, Hoboken, NJ 07030. *Infinite words and groups.*

I will talk about some new constructions in group theory that relate group actions, infinite Non-Archemidean words and length functions. (Received September 18, 2010)

1067-20-1096 **Benjamin Newton*** (newtonb@beloit.edu), Beloit College, 700 College St., Beloit, WI 53511. *On the number of maximal subgroups of a finite solvable group.* Preliminary report.

For a finite group G, let $\mathfrak{m}(G)$ be the number of maximal subgroups of G, and let $h(n) = \max\{\mathfrak{m}(G)|G$ is solvable and $|G| = n\}$. We present an upper bound $f(n)$ for $h(n)$ which improves existing upper bounds. We also identify values of n for which $f(n) = h(n)$. (Received September 18, 2010)

1067-20-1125 **Mark Pedigo*** (mark.pedigo@gmail.com), 10110 Sakura Drive, St. Louis, MO 63128. *Lower Central Series and Derived Series of the Free Nilpotent Groups of Finite Rank.* Preliminary report.

In their article, "On the derived subgroup of the free nilpotent groups of finite rank," Russell D. Blyth, Primož Moravec, and Robert F. Morse discuss the structure of the derived subgroups of the free nilpotent groups of finite rank. Specifically, they construct an isomorphism for such a derived subgroup in terms of a direct product of a nonabelian group and a free abelian group. In this preliminary report, we discuss generalizations of this research to members of the lower central series and derived series.
(Received September 19, 2010)

1067-20-1127 **Jason Behrstock** (Jason.Behrstock@lehman.cuny.edu) and **Ruth Charney*** (charney@brandeis.edu). *Divergence in right-angled Artin groups.*

The divergence, $div(\alpha, r)$, of a geodesic α measures the length of the shortest path between two points on α that stays outside the ball of radius r about their midpoint. We give a group theoretic criterion for determining when a geodesic in a right-angled Artin group G has super-linear divergence and show that this divergence is at most quadratic. We use this to describe the structure of the asymptotic cone of G and to show that every non-abelian subgroup of G has an infinite dimensional space of quasimorphisms. (Received September 19, 2010)

1067-20-1138 **Sarah Costrell*** (rhaas@smith.edu), Department of Mathematics and Statistics, Smith College, Northampton, MA 01063, and **Margaret Ewing**, **Jessica Lord** and **Viktoria Pardey**. *Groups and Change Ringing.* Preliminary report.

Change ringing is an art form that evolved in England several hundred years ago and is still practiced today. It involves bells of varying pitch being rung in sequences of permutations subject to certain constraints. In this talk we'll describe our investigation of the occurrence of various permutation groups in the construction of such sequences using the computational algebra package Magma. (Received September 19, 2010)

1067-20-1153 **Hans-Juergen Schneider*** (Hans-Juergen.Schneider@mathematik.uni-muenchen.de), Mathematisches Institut LMU, Theresienstrasse 39, 80333 Muenchen, Germany, and **Istvan Heckenberger** (i.heckenberger@googlemail.com), Philipps-Universitaet Marburg, Mathematik und Informatik, Hans-Meerwein-Strasse, 35032 Marburg, Germany. *Right coideal subalgebras of Nichols algebras and the Duflo order of the Weyl groupoid.*

This is a report on recent joint work with I. Heckenberger. The first main problem of the classification of pointed Hopf algebras is the structure of Nichols algebras over group algebras. We are studying systematically the Nichols algebra of a Yetter-Drinfeld module over any Hopf algebra (with bijective antipode) which is a finite direct sum of finite-dimensional irreducible Yetter-Drinfeld modules. In this general context in recent joint work with I. Heckenberger and N. Andruskiewitsch we define reflection maps and a Weyl groupoid. Under mild assumptions we associate a generalized root system (in the sense of Heckenberger and Yamane) to the Nichols algebra. Using these invariants it is possible to decide when the Nichols algebra is finite-dimensional. We obtain a coproduct formula which seems to be new even for the classical quantum groups. Then we describe the right coideal subalgebras of the Nichols algebra by words in the Weyl groupoid. As a special case we obtain a proof of a recent conjecture of Kharchenko which says that the number of right coideal subalgebras of the plus part of the quantum group of a semisimple Lie algebra is the order of the Weyl group. (Received September 19, 2010)

1067-20-1174 **Arturo Magidin*** (magidin@member.ams.org), Mathematics Department, 217 Maxim Doucet Hall, P.O. Box 41010, Lafayette, LA 70504-1010, and **Robert Fitzgerald Morse**, Department of Electrical Engineering, and Computer Science, University of Evansville, Evansville, IN 47722. *Capability of p-groups of class 2 and exponent p.* Preliminary report.

A group G is capable if there exists a group H such that $G \cong H/Z(H)$. A complete characterization of capability exists for abelian groups G that are direct sums of cyclic groups; metacyclic groups; extra-special p-groups; and some restricted classes (e.g., 2-generated p-groups of class 2).

For the class of p-groups of class 2 and exponent p, some necessary and some sufficient conditions are known, but no complete characterizations. We discuss some ways of constructing capable and non-capable groups in this class, and the following conjecture:

Conjecture. Let G be a p-group of class two and exponent p. Then G is capable if and only if for every generating set X of G, we have $\cap_{x\in X}[C_G(x), C_G(x)] = 1$. (Received September 19, 2010)

1067-20-1187 **Sang-hyun Kim*** (shkim@kaist.edu) and **Sang-il Oum** (sangil@kaist.edu). *Hyperbolic Surface Subgroups of One-ended Doubles of Free Groups.*

A double of a free group is the fundamental group of a graph of groups where there are two free isomorphic vertex groups and several infinite cyclic edge groups joining them, glued symmetrically. We prove that a double is one-ended if and only if it contains a hyperbolic surface group, when the free group has rank two or the set of amalgamating words contains each generator the same number of times. (Received September 19, 2010)

1067-20-1263 **Dennis F. Cudia***, 5343 Cunningham Road, Rockford, IL 61102. *The Boltzmann Principle and Degeneracy.*

The following unambiguous context free grammar G_m has productions based on the five degeneracies 1, 2, 3, 4, 6 of the genetic code. $L(G_m)$ is the set of <initiation> followed by any positive integer number of codons followed by <termination>.

$$\begin{array}{rl}
< Strt > & - \rightarrow < initiation > S' < termination > \\
S' & - >< codon > S' | < codon > \\
< codon > & - > D_1|D_2|D_3\ D_4\ D_6 \\
D_1 & - > AUG|UGG \\
D_2 & - > UUY|UAY|CAY|CAR|AAY|AAR|GAY|GAR|UGY \\
D_3 & - > AUU|AUC|AUA \\
D_4 & - > GUN|CCN|ACN|GCN|GGN \\
D_6 & - > UCY|UCR|AGY|CUY|CUR|UUR|CGY|CGR|AGR \\
N & - > Y|R \\
Y & - > U|C \\
R & - > A|G
\end{array}$$

Given any mature $mRNA$, mr, let N_1, N_2, N_3, N_4, N_6, respectively, be the number of codons in mr of degeneracy 1, 2, 3, 4, 6, respectively, and let $x = \Sigma N_i$. For each non-terminal X of G_m define the syntactic entropy of X, $SE(X)$, by $SE(X) = \ln W(X)$ where $W(X)$ is the number of righthand sides of X. (Received September 20, 2010)

1067-20-1326 **Cornelius Pillen*** (pillen@jaguar1.usouthal.edu), Department of Mathematics and Statistics, University of South Alabama, Mobile, AL 36688. *Cohomology of Finite Groups of Lie Type and Kostant's Partition Functions.* Preliminary report.

Let G be a simple algebraic group over an algebraically closed field k of prime characteristic $p > 0$ which is split over the prime field $\mathbb{F}_p$. Let $\mathrm{Fr} : G \to G$ denote the Frobenius map and set $q = p^r$. The fixed points of the rth iterate of the Frobenius map, denoted $G(\mathbb{F}_q)$, is a finite Chevalley group. In this talk we will study the cohomology groups $\mathrm{H}^i(G(\mathbb{F}_q), k)$ as well as $\mathrm{H}^i(G(\mathbb{F}_q), V)$, for certain irreducible modules V. By using techniques involving line bundle cohomology for the flag variety G/B, here B denotes a Borel subgroup of G, we are able to find relations with combinatorial data coming from Kostant's partition functions. This is joint work with Chris Bendel and Dan Nakano. (Received September 20, 2010)

1067-20-1346 **Indira Chatterji*** (indira.chatterji@math.cnrs.fr), **Guido Mislin**, **Christophe Pittet** and **Laurent Saloff-Coste**. *Subgroup distortion and bounded cohomology.*

We give a geometric way of characterizing Lie groups whose central subgroups are undistorted. (Received September 20, 2010)

1067-20-1392 **Daniel Groves***, Dept MSCS, 851 S. Morgan St., Chicago, IL 60607, and **Henry Wilton**, IL. *Conjugacy classes of solutions to systems of equations over hyperbolic groups.*

There is an algorithm to decide whether or not a system of equations and inequations over a torsion-free hyperbolic group has infinitely many conjugacy classes of solutions.

Time-permitting, I will discuss applications to the algorithmic study of limit groups over torsion-free hyperbolic groups. (Received September 20, 2010)

1067-20-1403 **Brian Parshall***, Department of Mathematics, Kerchof Hall, University of Virginia, Charlottesville, VA 22903. *Some results on stability for algebraic groups.*

This talk is joint work with Leonard Scott. For a normal subgroup N of a group G, an N-module Q is G-stable if $Q \cong Q^g$, $\forall g \in G$. If the action of N on Q extends G, then Q is clearly G-stable; the converse need not hold. A conjecture in the modular representation theory of reductive groups G asserts that the (obviously G-stable) projective indecomposable modules (PIMs) Q for the Frobenius kernels of G have a G-module structure. It is sometimes just as useful (for general Q) to know that a finite direct sum $Q^{\oplus n}$ has a compatible G-module structure (numerical stability). In previous work, the authors established numerical stability for PIMs. Here we discuss a more general setting for that result, working in the context of group schemes and a suitable version of G-stability, called strong G-stability. We obtain a determination of necessary and sufficient conditions for the existence of a compatible G-module structure on a strongly G-stable N-module, in the form of a cohomological obstruction which must be trivial precisely when the G-module structure exists. Our main result is achieved by giving an approach to killing the obstruction by tensoring with certain finite dimensional G/N-modules. (Received September 20, 2010)

1067-20-1454 **Joseph Evan*** (josephevan@kings.edu), Department of Mathematics & Computer Science, King's College, 133 N. River St., Wilkes-Barre, PA 18711. *Injectors in Direct Products of Finite Solvable Groups.*

In their book, "Finite Solvable Groups," Doerk and Hawkes ask if it is possible to characterize injectors for Fitting Sets in Finite Solvable Groups without reference to Fitting Sets. Recent work of Dark and Feldman, and Dark, Feldman, and Perez-Ramos provides a positive answer to this question.

Also recently, several authors have contributed to a project of characterizing subgroup properties in direct products of groups. In particular, nice characterizations have been found for normally embedded subgroups and subgroups satisfying the strong Frattini argument.

Given that in a finite solvable group, the set of injectors is between the set of normally embedded subgroups and the set of subgroups satisfying the strong Frattini argument with respect to set containment, there is potential for finding a nice condition that would characterize injectors in direct products of finite solvable groups. The purpose of this talk will be to provide results which describe when certain types of subgroups of direct products are injectors and discuss some necessary conditions for subgroups of direct products to be injectors. (Received September 21, 2010)

1067-20-1535 **Sang Rae Lee*** (srlee@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019-0315. *Geometry of Houghton's Group.*

Ken Brown showed Houghton's groups H_n are of type FP_n but not FP_{n+1} by examining the action of H_n on infinite dimensional complex. We show his proof can be improved so that H_n acts on horizontal level sets of a n-dimensional CAT(0) complex in view of Bestvina-Brady Morse function theory. We also show one can establish an isoperimetric inequality of the horizontal level set by using a certain pushing filling. (Received September 21, 2010)

1067-20-1546 **Luise-Charlotte Kappe*** (menger@math.binghamton.edu), Department of Mathematical Sciences, Binghamton, NY 13902-6000. *Nonabelian tensor products: the mystery of compatible actions.* Preliminary report.

Let G and H be groups acting on each other and acting on themselves by conjugation, where ${}^{g}g' = gg'g^{-1}$ and ${}^{h}h' = hh'h^{-1}$ for $g, g' \in G$ and $h, h' \in H$. We say the mutual actions are compatible if

$$ {}^{({}^{g}h)}g' = {}^{g}({}^{h}({}^{g^{-1}}g')) \quad \text{and} \quad {}^{({}^{h}g)}h' = {}^{h}({}^{g}({}^{h^{-1}}h')) $$

for all $g, g' \in G$ and $h, h' \in H$.

Compatible actions play a role in the nonabelian tensor product defined as follows.

Let G and H be groups which act on each other in a compatible fashion. Then the nonabelian tensor product $G \otimes H$ is the group generated by $g \otimes h$ for $g \in G$ and $h \in H$ with relations

$$gg' \otimes h = ({}^{g}g' \otimes {}^{g}h)(g \otimes h)$$
$$g \otimes hh' = (g \otimes h)({}^{h}g \otimes {}^{h}h').$$

The topic of this talk is to shed some light on the mystery of compatible actions. We will give a brief overview on what is known so far, provide some new results in case of cyclic groups, and discuss various approaches on how to unravel this mystery further. (Received September 21, 2010)

1067-20-1640 **Noel P. Brady*** (nbrady@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019, and **Dan P. Guralnik** and **Sang Rae Lee**. *Dehn functions and finiteness properties of subgroups of CAT(0) groups.*

We introduce a modification of right-angled Artin groups. These groups are the fundamental groups of non-positively curved cubical complexes, and they admit standard maps to $\mathbb{Z}$ just like right-angled Artin groups. Furthermore, the finiteness properties of the kernel subgroups are the same as those of the kernels of the corresponding right-angled Artin group. However, the geometry of the kernels is very different than in the right-angled Artin situation. (Received September 21, 2010)

1067-20-1650 **Elizabeth Wilcox*** (ewilcox@colgate.edu), Colgate University, Mathematics Department, 13 Oak Drive, Hamilton, NY 13346. *The base of a permutational wreath product.*

In 1964 Peter Neumann determined precisely which standard wreath products have a characteristic base and 30 years later Y. V. Bodnarchuk made progress in generalizing to transitive wreath products. In this talk we'll recall the definition of a wreath product and the base of such a group, as well as discuss the difference between standard, transitive, and permtutational wreath products. We will then look at the base of a permutational wreath product from a new perspective and generalize previous results to permutational wreath products. (Received September 21, 2010)

1067-20-1709 **Sang-hyun Ko,** (shkim@kaist.edu), Department of Mathematics, Tufts University, Medford, MA 02155, and **Paul E. Schupp*** (schupp@math.uiuc.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Generic Properties of Groups and Surface Subgroups.* Preliminary report.

An open question is whether or not one-ended hyperbolic groups contain fundamental groups of compact surfaces as subgroups. Schupp proved that if one fixes a genus g_0, then generically, groups do not contain a surface subgroup of genus less than or equal to g_0. We survey what is currently known about the general question. (Received September 22, 2010)

1067-20-1806 **Aaron Abrams**, **Noel Brady** and **Pallavi Dani***, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Moon Duchin** and **Robert Young**. *Pushing fillings in right-angled Artin groups.*

I will talk about a method for modifying fillings of spheres or cycles in the CAT(0) cube complex associated with a right-angled Artin group, and describe how this can be used to obtain sharp bounds on the higher Dehn functions of Bestvina-Brady groups. Similar ideas can be used to obtain estimates on higher divergence functions in right-angled Artin groups. These functions are a higher dimensional analog of the divergence of geodesics, and can be thought of as "Dehn functions at infinity". This is joint work with Aaron Abrams, Noel Brady, Moon Duchin, and Robert Young. (Received September 21, 2010)

1067-20-1820 **Michael R Bush*** (mbush@smith.edu), Dept. of Mathematics and Statistics, Smith College, Northampton, MA 01062. *Galois groups of p-class towers.*

The class tower of a number field consists of a certain sequence of field extensions. If the tower is finite it implies that the ring of integers of the base field can be embedded into a larger ring of integers in which unique factorization holds. That this is not always possible was established in the 1960s through the construction of examples of infinite p-class towers. In this talk I will describe a classification result for the p-groups of small order that are potentially Galois groups associated to finite towers where the base field is imaginary quadratic and p is an odd prime. Tools from computational group theory are employed. (Received September 21, 2010)

1067-20-1886 **George J. McNinch*** (mcninchg@member.ams.org), Tufts University, Dept of Mathematics, 503 Boston Ave, Medford, MA 02155. *Levi factors of linear algebraic groups.*

Let G be a linear algebraic group over a field k. If k has characteristic 0, then G has always a Levi factor, i.e. a complement to its unipotent radical. For any field k of characteristic p>0, however, there are linear algebraic groups over k which have no Levi factor.

Let K be a local field with residue field k, and let H be a reductive algebraic group over K. If Q is a parahoric group scheme attached to H, the special fiber G of Q is a linear algebraic group over k. This talk will discuss the author's recent result that the special fiber G has a Levi factor in case H splits over an unramified extension of K. (Received September 22, 2010)

1067-20-1912 **Leah R. Childers*** (leah.chiliders@gmail.com), Mathematics Department, Pittsburg State University, 1701 S Broadway, Pittsburg, KS 66762. *On Automorphisms 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 *symmetric (or hyperelliptic) Torelli group.* More specifically, we will investigate the group generated by Dehn twists about symmetric separating curves denoted $\mathcal{H}(S_g)$. Elements of $\mathcal{H}(S_g)$ act naturally on the symmetric separating curve complex, $C_{\mathcal{H}}(S)$. We will discuss that when $g \geq 5$, $\mathrm{Aut}(C_{\mathcal{H}}(S_g)) \cong \mathrm{SMod}^{\pm}(S_g)/\langle\iota\rangle$, where $\mathrm{SMod}(S_g)$ is the symmetric mapping class group and ι is a fixed hyperelliptic involution. Lastly we will give an algebraic characterization of Dehn twists about symmetric separating curves which will allow us to conclude that $\mathrm{Aut}(\mathcal{H}(S_g)) \cong \mathrm{SMod}^{\pm}(S_g)/\langle\iota\rangle$. (Received September 22, 2010)

1067-20-1960 **Dandrielle Lewis*** (dlewis5@binghamton.edu), Department of Mathematical Sciences, Binghamton, NY 13902-6000. *Characterizing Containment of Subgroups in a Direct Product.* Preliminary report.

Given a direct product of groups G and H and information on the subgroups of G and H, what can one say about the subgroup structure of $G \times H$? In 1889, Edouard Goursat proved a theorem that allows us to obtain the subgroup structure of a direct product by examining the sections of the direct factors. In this talk, we will discuss this result, characterize containment of subgroups in a direct product of groups and apply this result to examine the lattice of $Q \times Q$. (Received September 22, 2010)

1067-20-2002 **Aliska L. Gibbins***, 231 W. 18th Ave, Columbus, OH 43210. *Automorphisms of Buildings Constructed Via Covering Spaces.*

We discuss automorphisms of buildings constructed via covering spaces as in "'Examples of Buildings via Covering Spaces"' by Michael Davis. We will offer conditions under which these groups are Weyl transitive, strongly transitive, and construct a pre-root group system via lifts. (Received September 22, 2010)

1067-20-2121 **Stephen M. Gagola, Jr*** (gagola@math.kent.edu), Department of Mathematics, Kent State University, Kent, OH 44242. *Counting subgroups of S_{n+1} normalized by and coprime to a nonabelian regular subgroup of order n.* Preliminary report.

Let H be a regular subgroup of the symmetric group S_n (regarded as a subgroup of S_{n+1}) and let $\mathcal{C}$ be the collection of nontrivial subgroups of S_{n+1} of order coprime to $|H|$ that are normalized by H. If $\mathcal{C}$ is nonempty then H is necessarily a Frobenius complement and in a previous report we determined $|\mathcal{C}|$ when H is abelian (necessarily cyclic). In the present work, we extend this to the case when H is nonabelian. (Received September 22, 2010)

1067-20-2176 **Margaret H Dean**, **Gretchen Ostheimer** and **Marcos Zyman***, Mathematics Department, 199 Chambers St., New York, NY 10007. *IA-automorphisms of wreath products.*

The IA-group of a group G is the kernel of the natural homomorphism from $AutG$ to $Aut(G/G')$. We discuss some results involving the structure of the IA-group of the wreath product of a finitely generated free abelian group by another. Using Magnus' embedding, we also relate these results to the IA-group of a free metabelian group. (Received September 22, 2010)

1067-20-2222 **Dan Boros*** (boros@math.ohio-state.edu), Ohio State University, Department of Mathematics, 231 W 18 Ave, Columbus, OH 43210. *On weighted ℓ^2-Betti numbers of Coxeter groups.* Preliminary report.

We provide explicit calculations of weighted ℓ^2-Betti numbers for some concrete examples of right-angled Coxeter groups. Most of the examples considered have one-dimensional or two-dimensional nerve. (Received September 22, 2010)

1067-20-2225 **Berit Nilsen Givens*** (bngivens@csupomona.edu), 3801 W Temple Ave, Department of Mathematics and Statistics, Pomona, CA 91768, and **Amber Rosin** (arrosin@csupomona.edu), 3801 W Temple Ave, Department of Mathematics and Statistics, Pomona, CA 91786. *The Interassociates of the Bicyclic Semigroup.*

The bicyclic semigroup $C = \langle p, q \mid p \cdot q = 1 \rangle$ is well known in semigroup theory. For each pair of nonnegative integers m and n, we consider the semigroup $(C_{m,n}, *_{m,n})$ with the same underlying set as $(C, \cdot)$ and with operation $w *_{m,n} v = w \cdot q^m p^n \cdot v$. These are precisely the semigroups that interassociate with C, that is, those semigroups for which $w \cdot (v * z) = (w \cdot v) * z$ and $w * (v \cdot z) = (w * v) \cdot z$. We show that no two of these semigroups are isomorphic. (Received September 22, 2010)

1067-20-2285 **Thomas Koberda*** (koberda@math.harvard.edu), Department of Mathematics, Harvard University, 1 Oxford St., Cambridge, MA 02138. *Faithful actions of automorphisms on the space of orderings of a group.*

We study the space of left– and bi–invariant orderings on a torsion–free nilpotent group G. We will show that generally the set of such orderings is equipped with a faithful action of the automorphism group of G. We prove an extension result which allows us to establish the same result when G is assumed to be merely residually torsion–free nilpotent. In particular, we obtain faithful action of mapping class groups of surfaces. We will draw connections between the structure of orderings on residually torsion–free nilpotent, hyperbolic groups and their Gromov boundaries, and we show that in those cases a faithful $\mathrm{Aut}(G)$–action on the boundary is equivalent to a faithful $\mathrm{Aut}(G)$ action on the space of left–invariant orderings. (Received September 22, 2010)

1067-20-2403 **Yael Algom-Kfir***, yael@math.utah.edu, and **Mladen Bestvina**, bestvina@math.utah.edu. *Asymmetry of the Lipschitz metric on Outer Space.*

Outer Space is a topological model for $\mathrm{Out}(F_n)$, the outer automorphism group of F_n. Recently attempts have been made to endow Outer Space with a metric, the Lipschitz metric, and explore its properties. The Lipschitz metric on Outer Space is has proven to be useful as shown the recent proof of the classification of $\mathrm{Out}(F_n)$ elements by Mladen Bestvina, and the proof that axes in the Cayley graph of irreducible elements of $\mathrm{Out}(F_n)$ are Morse by Yael Algom-Kfir. However, this metric is not symmetric, in fact $d(x, y)$ can be arbitrarily large while $d(y, x)$ remains bounded. In this talk we will discuss the reasons for the asymmetry and provide conditions for $d(x, y)/d(y, x)$ to be bounded. (Received September 23, 2010)

1067-20-2414 **Igor Belegradek** and **G. Christopher Hruska*** (chruska@uwm.edu), Department of Mathematical Sciences, University of Wisconsin–Milwaukee, PO Box 413, Milwaukee, WI 53201-0413. *Hyperplane arrangements in negatively curved manifolds and relative hyperbolicity.*

Let M be a finite volume manifold with pinched negative curvature, and let S be a codimension–2 totally geodesic immersed submanifold. We show that, in certain cases, the fundamental group of $M - S$ is relatively hyperbolic. Our main technique is to examine the geometry of the universal branched cover of M with branch locus S. This branched cover is a $\mathrm{CAT}(-1)$ space Y on which the fundamental group of $M - S$ acts. However Y is not locally compact, and the action is not proper. Nevertheless, an examination of its geometry reveals the structure of relative hyperbolicity. (Received September 23, 2010)

1067-20-2422 **Talia Fernos*** (fernos@math.huji.ac.il) and **Alain Valette** (Alain.Valette@unine.ch). *Reduced 1-cohomology and relative (T).*

The celebrated theorems of Delorme (1977) and Guichardet (1972) establish the equivalence between property (T) and the vanishing of 1-cohomology, where the coefficients are taken in a unitary representation. In 2000 Shalom proved that the (a priori) weaker condition of the vanishing of reduced 1-cohomology is in fact equivalent to property (T) for the class of compactly generated groups. In 2005-2006 de Cornulier, Jolissaint, and Fernos independently showed that the vanishing of the restriction map on 1-cohomology is equivalent to relative property (T). One may ask if the relative version of Shalom's theorem is true. In a joint work with Valette we exhibit a large class of non-compact amenable group-pairs where the restriction map on reduced 1-cohomology always

vanishes. Since amenable groups can not have relative property (T) with respect to non-compact subgroups, our result gives a strong negative answer to the above question. (Received September 23, 2010)

22 ► Topological groups, Lie groups

1067-22-172 **William M. McGovern*** (`mcgovern@math.washington.edu`), Department of Mathematics, Box 354350, University of Washington, Seattle, WA 98195. *Rational smoothness of K-orbit closures in flag varieties.*

Let K be a symmetric subgroup of a complex reductive group G. I will survey the known results on the characterization of the K-orbits in the flag variety G/B with rationally smooth closure, mostly via the combinatorial notion of pattern avoidance. All of the classical cases but one have been settled, but the last one presents serious technical difficulties. (Received July 28, 2010)

1067-22-232 **Lou van den Dries** and **Isaac M Goldbring*** (`isaac@math.ucla.edu`). *Globalizing locally compact local groups.*

Roughly speaking, a local group is a topological group for which only certain products are defined. It is assumed that the set of pairs of elements for which the product is defined is open. For example, any open neighborhood of the identity in a topological group is a local group; such a local group is said to be *globalizable.* The question of which local groups are globalizable has been a central question in the study of local groups. Cartan established that every local Lie group is globalizable and this result was extended by Goldbring to the class of locally euclidean local groups by solving the local version of Hilbert's Fifth Problem (Local H5). Using some of the nonstandard results which appeared in the proof of the Local H5, we show that every locally compact local group is globalizable. The aforementioned result is in some sense optimal for it is known that there are local Banach-Lie groups which are not globalizable. (Received August 10, 2010)

1067-22-323 **Sigurdur Helgason*** (`helgason@mit.edu`), Department of Mathematics, MIT, Cambridge, MA 02478. *Eigenspace representations for homogeneous spaces.*

In this lecture we describe various results (old and relatively new) about eigenspace representation for homogeneous spaces G/H. This refers to the representations of G on the joint eigenspaces (functions and vector bundle sections) of invariant differential operators on G/H. The results are richest when the algebra D(G/H) of invariant differential operators is commutative; if not one can restrict to commutative subalgebras. (Received August 22, 2010)

1067-22-434 **David E Nadler*** (`denadler@gmail.com`), Department of Mathematics, Northwestern University, 2033 Sheridan Rd, Evanston, IL 60208. *The Geometric Nature of the Fundamental Lemma.*

The Fundamental Lemma is a somewhat obscure combinatorial identity introduced by Robert P. Langlands as an ingredient in the theory of automorphic representations. After many years of deep contributions by mathematicians working in representation theory, number theory, algebraic geometry, and algebraic topology, a proof of the Fundamental Lemma was recently completed by Ngô Bau Châu, for which he was awarded a Fields Medal. Our aim here is to touch on some of the beautiful ideas contributing to the Fundamental Lemma and its proof. We highlight the geometric nature of the problem which allows one to attack a question in p-adic analysis with the tools of algebraic geometry. (Received September 03, 2010)

1067-22-666 **Firas Y Hindeleh*** (`hindelef@gvsu.edu`), 1 Campus Dr., Allendale, MI 49401, and **Gerard Thompson** (`gerard.thompson@utoledo.edu`), 2801 W Bancroft St, Toledo, OH 43606. *Killing's equations for invariant metrics on Lie groups.*

We investigate symmetry and curvature properties of a right-invariant metric on a Lie group. This talk will consider Lie groups in dimension two and three and will focus on the solutions of Killing's equations. A striking result is that several of the three-dimensional Lie groups turn out to be spaces of constant curvature. (Received September 13, 2010)

1067-22-677 **Siddhartha Sahi*** (`sahi@math.rutgers.edu`), Rutgers University, Hill Center Busch Campus, New Brunswick, NJ 08903. *Invariant functionals on Speh representations.*

Speh representations are an interesting family of unitary representations for GL(2n,R)that were first discovered by Birgit Speh in the residual spectrum. They arise as Zuckerman derived functor modules from unitary characters of GL(n,C), have a Hilbert space realization due to Sahi-Stein, and play an important role in the Vogan-Tadic classification of the unitary representations of GL(n). Let H=Sp(2n,R), U=U(n), and let P be the Siegel parabolic subroup of H.

Using automorphic techniques Offen-Sayag have shown (unpublished) that the space of H-invariant distribution on the Speh representations has dimension 0 or 1, according as n is odd or even. We give a strengthening of this result, by showing that for (1) odd n there are no U-invariant distributions (2) for even n there is a 1-dimensional space of P-invariant distributions.

This is joint work with Dmitry Gurevich and Eitan Sayag. (Received September 13, 2010)

1067-22-909 **Gestur Olafsson*** (olafsson@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Angela Pasquale**. *Ramanujan's master theorem for symmetric spaces.*

Ramanujan's master theorem from 1913 relates the Fourier transform of a function f on the torus with it's Fourier transform on the group of positive reals

$$\int_0^\infty x^{-s-1}\left(\sum_{k=0}^{\infty}(-1)^k a(k)x^k\right)dx = -\frac{\pi}{\sin \pi s}a(s)\,.$$

In the work of Hardy and Ramanujan, this relation turned out to be quite useful in the theory of hypergeometric functions. Hence the Ramanujan *master theorem*. In 1996 this relation was generalized to symmetric spaces of rank one by W. Bertram and by H. Ding, K. Gross, and D. Richards to symmetric cones. In 1997 H. Ding extended it to Hermitian symmetric spaces. In this talk we present our joint work with A. Pasquale on the Ramanujan master theorem for symmetric spaces and generalizations. The duality between the torus and $\mathbb{R}^+$ is replaced by the duality between symmetric spaces of the compact type U/K and of noncompact type G/K. The sum on the left hand side is the Fourier expansion of f on a maximal torus in U/K and the right hand side is the spherical Fourier transform of f on G/K. (Received September 16, 2010)

1067-22-1118 **Matthew Housley*** (housley@math.utah.edu), 155 South 1400 East Room 233, Salt Lake City, UT 84112. *Closed form multiplicity polynomials attached to hook type Springer fibers for $SL(n,\mathbb{C})$.*

We discuss a class of polynomials attached to Springer fiber components that has application to the computation of associated cycles for Harish-Chandra modules. The span of polynomials attached to components of a specified fiber gives a Weyl group representation. In type A, this is isomorphic to the Springer representation attached to the fiber and to a representation on a cell of Harish-Chandra modules. We exploit these isomorphisms to write down closed forms of polynomials for all hook type Springer fibers over $\mathfrak{sl}(n,\mathbb{C})$. These results build on work of Leticia Barchini and Roger Zierau [1].

References

[1] L. Barchini and R. Zierau. Certain components of Springer fibers and associated cycles for discrete series representations of $SU(p,q)$. *Represent. Theory*, 12:403-434, 2008. With an appendix by Peter E. Trapa.

(Received September 19, 2010)

1067-22-1219 **Markus Hunziker** and **Mark R. Sepanski*** (Mark_Sepanski@baylor.edu), Department of Mathematics, Baylor University, One Bear Place #97328, Waco, TX 76798-7328. *Distinguished orbits and the L-S category of simply connected compact Lie groups.*

We show that the Lusternik-Schnirelmann category of a simple, simply connected, compact Lie group G is bounded above by the sum of the relative categories of certain distinguished conjugacy classes in G corresponding to the vertices of the fundamental alcove for the action of the affine Weyl group on the Lie algebra of a maximal torus of G. (Received September 20, 2010)

1067-22-1242 **Juhyung Lee*** (juhylee@math.okstate.edu), MS438 OSU, Stillwater, OK 74078. *A realization of an irreducible unitary representation.*

To give a realization of an irreducible unitary representation of $G = GL(2n, R)$, we use the usual G-invariant Hermitian form coming from the standard G-intertwining operator between degenerate principal series representations. It is known that the zeta distribution is given by the G-intertwining operator and has a meromorphic continuation to all of $\mathbf{C}$. The formula for the Fourier transformation of $|\det(x)|^{-t}$, as a distribution, gives a functional equation between the zeta distributions which is known as the Fundamental Theorem of Prehomogeneous vector spaces.

To show that the Hermitian form is positive definite, we need to extend the formula, which is well-known for Schwartz functions, to the larger class of functions in the $\bar{N}$-picture for a degenerate principal series representation. However, there is no range where both integrals converge (except the n=1 case). Therefore, we extend the notion of the zeta distributions so that they have meromorphic continuations for functions in the $\bar{N}$-picture and the functional equation holds as meromorphic functions. The functional equation between the meromorphic family of zeta distributions can be used to construct the inner product on the $\bar{N}$-picture explicitly. (Received September 20, 2010)

1067-22-1243 **Mark Colarusso*** (mark.colarusso.1@ulaval.ca), Pavillon Alexandre-Vachon, 1045 Av. de la Medecine, Québec, QC G1V 0A6, Canada, and **Sam Evens** (sevens@nd.edu), 255 Hurley Hall, University of Notre Dame, Notre Dame, IN 46556-4618. *The geometry of Gelfand-Zeitlin fibres.* Preliminary report.

In 2006, Kostant and Wallach constructed an integrable system on the $n \times n$ complex matrices $\mathfrak{gl}(n, \mathbb{C})$ using a classical analogue of the Gelfand-Zeitlin subalgebra of the universal enveloping algebra. This integrable system can be viewed as a complexified version of the one studied by Guillemin and Sternberg on the $n \times n$ Hermitian matrices, which is related to the classical Gelfand-Zeitlin basis via geometric quantization.

In this talk, we discuss joint work with Sam Evens in which we develop a geometric description of the fibres of the moment map for the complexified Gelfand-Zeitlin system studied by Kostant and Wallach. In particular, we show that the generic components of the nilfibre correspond to certain Borel subalgebras constructed using the theory of $K = GL(n-1, \mathbb{C}) \times GL(1, \mathbb{C})$ orbits on the flag variety. We discuss our current work in describing all generic moment map fibres using an analogue of the Grothendieck resolution adapted to study the Gelfand-Zeitlin system. (Received September 20, 2010)

1067-22-1247 **Sam Evens*** (sevens@nd.edu). *Intersections of Schubert cells and orbits of real semisimple Lie groups on the flag variety.*

This talk is based on joint work with Jiang-Hua Lu. Let G be a complex semisimple Lie group with real form G_0 and Borel subgroup B. We regard B as the identity coset eB in G/B, and assume that the G_0-orbit G_0eB is open in G/B. In this talk, I will explain an algorithm for determining whether an arbitrary G_0-orbit on G/B meets a Schubert cell BwB, for w in the Weyl group. I will explain additional results about the geometry of the intersections of these orbits and their closures. (Received September 20, 2010)

1067-22-1287 **Kendall Williams*** (kendallist@yahoo.com). *Elements of Polynomials evaluated at points of βS.* Preliminary report.

Given a set S with the discrete topology where both $(S, \cdot)$ and $(S, +)$ are semigroups, one may extend the operations on S to βS, the Stone-Čech Compactification of S. βS is comprised of the ultrafilters on S. With respect to each of its operations individually, βS is a compact right topological semigroup containing S in its topological center.

Let $k \in \mathbb{N}$ and $g(z_1, z_2, \ldots, z_k)$ be an arbitrary polynomial with coefficients in S. We shall evaluate g on certain elements of βS, say $p_1, p_2, \ldots, p_k$; making $g(p_1, p_2, \ldots, p_k)$ itself an ultrafilter on S. We characterize subsets of S that must be elements of the ultrafilter $g(p_1, p_2, \ldots, p_k)$. (Received September 20, 2010)

1067-22-1295 **Roger Zierau*** (zierau@math.okstate.edu), Mathematics Department, Oklahoma State University, Stillwater, OK 74078, and **Leticia Barchini**, Mathematics Department, Oklahoma State University, Stillwater, OK 74078. *Square integrable harmonic spinors.* Preliminary report.

We consider the cubic Dirac operator on a reductive homogeneous space G/H. The space of harmonic spinors is the kernel. A space of square integrable harmonic spinors is defined. Since a homogeneous bundle on G/H typically has an indefinite invariant metric, square integrability necessarily is in terms of a noninvariant inner product. We describe this, and how a G-invariant hermitian form is defined on the L_2-space. A theorem will be stated that gives a condition for the L_2 space of harmonic spinors to be nonzero. (Received September 20, 2010)

1067-22-1404 **Maria Gordina**, **Leonard Gross*** (gross@math.cornell.edu) and **S. G. Rajeev**. *Another approach to Lie's third theorem in infinite dimensions.*

The proof of Lie's third theorem by Duistermaat and Kolk (2000) produces a Lie group G with given Lie algebra $\mathfrak{g}$ by constructing G as a quotient of a group of paths into $\mathfrak{g}$ modulo a subgroup of this path group.

Spaces of paths into a Lie algebra have been used in a number of diverse settings, including heat kernel analysis on Lie groups, control theory for rough paths, and K.T. Chen forms and their applications. Each of these studies encodes a given path as an element of a tensor algebra over $\mathfrak{g}$. We are going to use this encoding, along with natural heat kernel norms on the tensor algebra, to give another proof of Lie's third theorem, applicable to some infinite dimensional Lie algebras. This improves on the authors' previous approach. (Received September 20, 2010)

1067-22-1450 **Brant Jones*** (brant@math.jmu.edu), Department of Mathematics and Statistics, MSC 1911, Harrisonburg, VA 22807, and **Anne Schilling**. *Affine structures for certain E_6 crystals.*

Let $\mathfrak{g}$ be an affine Kac–Moody algebra and $U_q'(\mathfrak{g})$ be the associated quantized affine algebra. Kirillov–Reshetikhin modules are finite dimensional $U_q'(\mathfrak{g})$-modules labeled by a node r of the Dynkin diagram together with a nonnegative integer s. It is expected that each Kirillov–Reshetikhin module has a crystal basis. In this talk, we focus on type $E_6^{(1)}$ for which Chari has given the decomposition of Kirillov–Reshetikhin modules into classical highest-weight modules. We extend the classical crystals for these modules to give an explicit combinatorial realization of the Kirillov–Reshetikhin crystals when r is 1, 6 or 2 in the Bourbaki labeling and s is arbitrary. This realization is based on the technique of promotion that has been used for other types by Shimozono and Fourier, Okado, Schilling.

This is joint work with Anne Schilling. (Received September 21, 2010)

1067-22-1498 **Mark Colarusso*** (mark.colarusso.1@ulaval.ca), Pavillon Alexandre-Vachon, 1045 Av. de la Medecine, Quebec, QC G1V 0A6, Canada, and **Sam Evens** (sevens@nd.edu), 255 Hurley Hall, University of Notre Dame, Notre Dame, IN 46556-4618. *A nonlinear Gelfand-Zeitlin integrable system on the Poisson dual Lie group $GL(n,\mathbb{C})^*$.*

In 2006, Kostant and Wallach constructed an integrable system on the $n \times n$ complex matrices $\mathfrak{gl}(n,\mathbb{C})$ using a classical analogue of the Gelfand-Zeitlin subalgebra of the universal enveloping algebra. This integrable system can be viewed as a complexified version of the one studied by Guillemin and Sternberg on the $n \times n$ Hermitian matrices.

In this talk, we will discuss joint work with Sam Evens in which we construct a nonlinear version of Kostant and Wallach's Gelfand-Zeitlin system for the Poisson dual Lie group $GL(n,\mathbb{C})^*$. We show that the corresponding Hamiltonian vector fields are complete and integrate to a holomorphic action of $\mathbb{C}^{\frac{n(n-1)}{2}}$ on $GL(n,\mathbb{C})^*$. Orbits of $\mathbb{C}^{\frac{n(n-1)}{2}}$ of dimension $\frac{n(n-1)}{2}$ form Lagrangian submanifolds of generic symplectic leaves of $GL(n,\mathbb{C})^*$. We will also discuss ongoing work in studying the geometry of this group action and the algebraic integrability of the nonlinear Gelfand-Zeitlin system. (Received September 21, 2010)

1067-22-1929 **William Graham*** (wag@math.uga.edu) and **Sam Evens** (sevens@nd.edu). *The Belkale-Kumar cup product and relative Lie algebra cohomology.*

We study the Belkale-Kumar family of cup products on the cohomology of a generalized flag variety. We give an alternative construction of the family using relative Lie algebra cohomology, and in particular, identify the Belkale-Kumar cup product for every parameter. As a consequence, we extend a fundamental disjointness result of Kostant to a family of Lie algebras. (Received September 22, 2010)

1067-22-2171 **John D Foley*** (jfoley@ucsd.edu). *Comparing Kac-Moody Groups over $\mathbb{C}$ and Finite Fields via Homotopy Theory.*

A new homotopy decomposition for the positive "unipotent" subgroup, U^+, of a group with a RGD system is presented in this talk. As an application, a map $BK(\overline{\mathbb{F}}_p) \to BK$ is constructed for a complex Kac-Moody group K and the discrete Kac-Moody group $K(\overline{\mathbb{F}}_p)$ over $\mathbb{F}_p$ of the same type by using known homotopy decompositions to employ the previously studied Lie case. This new map is a $\mathbb{F}_p$-homology isomorphism in analogy to the Lie case appearing in Friedlander, Eric M. and Mislin, Guido *Cohomology of classifying spaces of complex Lie groups and related discrete groups.* Comment. Math. Helv. 59 (1984), no. 3, 347–361. If K is a reductive Lie group, localizing at a prime $q \neq p$ and taking homotopy fixed points with respect to p^k-th unstable Adams operation, ψ^k, recovers the maps $BK(\mathbb{F}_{p^k})^\wedge_q \to (BK^{h\psi^k})^\wedge_q$ Friedlander and Mislin used to construct $BK(\overline{\mathbb{F}}_p) \to BK$ for reductive Lie groups. Here, cohomology calculations are given to compare $(BK^{h\psi^k})^\wedge_q$ and $BK(\mathbb{F}_{p^k})^\wedge_q$ for some rank two, non-Lie examples. (Received September 22, 2010)

1067-22-2273 **Oliver Gjoneski*** (gjoneski@math.duke.edu), Durham, NC 27705. *Multi-Variable Period Polynomials Associated to Cusp Forms for $SL_2(\mathbb{Z})$.* Preliminary report.

In this paper we explore the notion of multi-variable period polynomials associated to cusp forms for $SL_2(\mathbb{Z})$. There are two equally important aspects of this problem, the homological, involving the definition of three-dimensional cells in the symmetric space $GL_3(\mathbb{R})/O_3(\mathbb{R})A(\mathbb{R})$, and the cohomological, involving holomorphic Eisenstein series associated to cusp forms on the boundary of this symmetric space. Delving deeper, we hope to present more insight into the Eilenberg-Maclane cohomology of $GL_3(\mathbb{Z})$. (Received September 22, 2010)

1067-22-2391 **T. Christine Stevens*** (stevensc@slu.edu), Dept. of Mathematics and Computer Science, Ritter Hall 104, 220 N. Grand Blvd., St. Louis, MO 63103. *Changing the rate at which a sequence in $\mathbb{R}^n$ is forced to converge to zero.*

We continue our investigation of translation-invariant metrics for $\mathbb{R}^n$ that are defined by choosing a sequence $\{v_i\}$ of elements of $\mathbb{R}^n$ and specifying the rate $\{p_i\}$ at which it converges to zero. If $\{v_i\}$ goes to infinity sufficiently fast in the usual topology, then such a metric always exists, and its translation-invariance guarantees that it will make $\mathbb{R}^n$ an additive topological group. In previous papers (joint with J.W. Short), we investigated the effect on the topology of changing the "converging sequence," and we now determine the consequences of changing the "rate sequence." The main theorem is that two "rate sequences" $\{p_i\}$ and $\{q_i\}$ will determine the same topology for $\mathbb{R}^n$ if and only if the ratios $\{p_i/q_i\}$ and $\{q_i/p_i\}$ are bounded. These results have implications for the study of minimal groups and of Lie groups of transformations. (Received September 23, 2010)

26 ► Real functions

1067-26-399 **Robert J. Blodgett*** (Robert.Blodgett@fda.hhs.gov), Food and Drug Administration, 5100 Paint Branch Parkway, College Park, MD 20740. *A simple, general proof of Descartes' rule of signs.*

The application of basic calculus procedures show that Descartes' rule of signs is more than a specialized trick that applies to just polynomials. It is combined with the Budan-Fourier theorem and shown to apply to a very general family of functions. Calculus is shown to verify and extend the classical result beyond the original intent. (Received September 01, 2010)

1067-26-821 **Tobias Kaiser**, **Jean-Philippe Rolin** and **Patrick Speissegger*** (speisseg@math.mcmaster.ca), Department of Mathematics & Statistics, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada. *Super-exact quasi-analytic classes and o-minimality.*

Quasi-analytic classes of functions with super-exact asymptotic expansions arise in Ilyashenko's solution of Dulac's problem. We hope to prove that some of these classes generate o-minimal structures. These structures would be exponentially, but not polynomially, bounded. I will describe Ilyashenko's construction and outline our plan for proving o-minimality. (Received September 15, 2010)

1067-26-1725 **Raluca Felea**, **Allan Greenleaf** and **Malabika Pramanik*** (malabika@math.ubc.ca), 1984 Mathematics Road, Vancouver, BC V6T 1Z2, Canada. *Sobolev estimates for an FIO calculus associated to marine seismic imaging.*

We establish sharp L^2-Sobolev estimates for classes of pseudodifferential operators with singular symbols whose non-pseudodifferential (Fourier integral operator) parts exhibit two-sided fold singularities. The operators considered include both singular integral operators along two-dimensional curves with simple inflection points and normal operators arising in linearized seismic imaging in the presence of fold caustics. This is joint work with Raluca Felea and Allan Greenleaf. (Received September 21, 2010)

28 ► Measure and integration

1067-28-55 **Kate E. Ellis** (kellis1@csustan.edu), **Michel L. Lapidus** (lapidus@math.ucr.edu), **Michael C. Mackenzie** (michael.mackenzie@uconn.edu) and **John A. Rock*** (jrock@csustan.edu). *Partition zeta functions of self-similar measures.*

For an Iterated Function System (IFS) on the unit interval weighted by a probability vector we define a multifractal spectrum for the self-similar Borel measure uniquely determined by the weighted IFS as the abscissae of convergence of its partition zeta functions. Partition zeta functions are Dirichlet series determined by the self-similar Borel measure and a naturally defined sequence of partitions. These partition zeta functions are indexed by coarse Holder regularity and we show that the corresponding abscissae of convergence equal the Hausdorff dimension of corresponding Besicovitch subsets of the support of the measure. In the case of the binomial measure, for instance, the classical Hausdorff multifractal spectrum is recovered. (Received July 01, 2010)

1067-28-79 **Kate E Ellis*** (`kellis1@csustan.edu`). *Counting Formulas and Partition Zeta Functions of Atomic Measures.*

It has been shown that the geometric counting function of a fractal string can be expressed in terms of a sum over its complex dimensions. In this talk, we will develop and analyze the counting functions associated with a slightly generalized form of an atomic measure which is supported on the boundary of a Cantor-like fractal string. Following the development of the geometric counting function of a fractal string, the counting functions we will consider make use of regularity, partition zeta functions, and complex dimensions indexed by regularity. (Received July 17, 2010)

1067-28-140 **Bryan Archer**, **Rees Dooley**, **Reid Kelley**, **Alyssa Leone** and **Patrick Orchard***, Department of Mathematics, University of Oklahoma, Norman, OK 73019-0315. *Orthogonal and Maximal Sets for Bernoulli Measures.* Preliminary report.

We consider orthogonal and maximal sets on $L^2(X_\lambda, \mu_\lambda)$ where μ_λ is the Hutchinson measure associated with the Bernoulli Iterated Function System (IFS) for $\lambda \in (0,1)$ and X_λ is the support of the measure. By previous theorems, we have an orthonormal basis of exponential frequencies for our space where $\lambda = \frac{1}{2n}$, which we denote $\Gamma_{\frac{1}{2n}}$. We investigate sets $c\Gamma_{\frac{1}{2n}}$ where c is an odd integer dependent on 2n. We prove that the set $3\Gamma_{\frac{1}{4}} \cup \{x : x = -4^n(1 + \sum_{j=n+1}^{p} a_j 4^j),\, p < \infty,\, n \in \mathbb{N}_0,\, a_j \in \{0, 3\}\ \}$ is an orthogonal and maximal set for the space $L^2(X_{\frac{1}{4}}, \mu_{\frac{1}{4}})$, but is probably not an orthonormal basis for the set. (Received July 27, 2010)

1067-28-1291 **David P. Kimsey*** (`kimsey@drexel.edu`), Department of Mathematics, 3141 Chestnut Street, Philadelphia, PA 19104, and **Hugo J. Woerdeman** (`hugo@math.drexel.edu`), Department of Mathematics, 3141 Chesnut Street, Philadelphia, PA 19104. *The truncated matrix-valued K-moment problem on $\mathbb{R}^d$, $\mathbb{C}^d$, and $\mathbb{T}^d$.* Preliminary report.

The truncated matrix-valued K-moment problem on $\mathbb{R}^d$, $\mathbb{C}^d$, and $\mathbb{T}^d$ will be considered. The matrix-valued truncated K-moment problem on $\mathbb{R}^d$ requires necessary and sufficient conditions for a sequence of Hermitian matrices $\{S_\gamma\}_{\gamma\in\Gamma}$, where Γ is a finite subset of $\mathbb{N}_0^d$, to be the corresponding moments of a positive matrix-valued Borel measure σ and also the support of σ must lie in some given non-empty set $K \subseteq \mathbb{R}^d$, i.e.

$$S_\gamma = \int_{\mathbb{R}^d} \xi^\gamma d\sigma(\xi), \quad \gamma \in \Gamma, \tag{1}$$

and

$$\operatorname{supp} \sigma \subseteq K. \tag{2}$$

Given a set $K \subseteq \mathbb{R}^d$ and a finite sequence, indexed by a certain family of finite subsets of $\mathbb{N}_0^d$, of Hermitian matrices we obtain necessary and sufficient conditions for the existence of a finitely atomic measure which satisfies (1) and (2). In particular, our result can handle the case when the indexing set that corresponds to the powers of total degree at most $2n+1$. We will also discuss a similar result in the complex and polytorus setting. (Received September 20, 2010)

30 ► Functions of a complex variable

1067-30-59 **Maher M.H. Marzuq*** (`maher_marzuq@yahoo.com`), Maher M.H. Marzuq, Plymouth, MA 02360. *Interpolation Sequence for the Spaces $H_+^q(\varphi)(q \geq 1)$*

Let φ be a subadditive increasing real valued function defined on $[0, \infty)$ and which satisfies $\varphi(x) = 0$ if and only if $x = 0$. For $q \geq 1$ we define $H^q(\varphi)$ to be the set of all functions f which are analytic in the open unit disc and satisfy

$$\sup_{0\leq r<1} \int_0^{2\pi} [\varphi(|f(re^{i\theta})|]^d \, d\theta < \infty$$

and $H_+^q(\varphi)$ to be the subspace of $H^q(\varphi)$ of functions which satisfy

$$\lim_{r\to 1} \int_0^{2\pi} [\varphi(|f(re^{i\theta})|)^q \, d\theta = \int_0^{2\pi} [\varphi(|f(e^{i\theta})|)]^q \, d\theta.$$

In this paper we prove some interpolation theorems for $H_+^q(\varphi)$. (Received July 06, 2010)

1067-30-217 **Tim Ferguson*** (`tjferg@umich.edu`), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Regularity of Solutions to Extremal Problems in Bergman Spaces.*

We discuss linear extremal problems in the Bergman space A^p of the unit disc for $1 < p < \infty$. Given a functional in the dual space of A^p with representing kernel $k \in A^q$, where $1/p + 1/q = 1$, we discuss how the regularity of

k is related to the regularity of the extremal function F. An early result in this direction is Ryabykh's theorem, which says that if k is in the Hardy space H^q, then F must be in H^p. We will discuss Ryabykh's theorem and indicate some extensions of it that we have found. (Received September 03, 2010)

1067-30-269 **Craig A. Nolder*** (nolder@math.fsu.edu), Department of Mathematics, Florida State University, Tallahassee, FL 32306. *The Hypercomplex Beurling-Ahlfors Transform.*

We give a bound on the hypercomplex Beurling-Ahlfors transform, also called the Π-operator, as an operator on $L^p, p > 1$. This operator reduces the the usual Beurling-Ahlfors transform in the plane where calculating this norm has motivated much research. The operator is expressed as a linear combination of second order Riesz transforms. (Received August 15, 2010)

1067-30-367 **Ara S. Basmajian***, 83 Hillcrest ave., Manhasset, NY 11030. *Involutions and the word length of the Mobius group.*

We consider the word length of $\text{Möb}^+(n)$, the orientation preserving isometries of hyperbolic n-space, with respect to various generating sets. When the generating set consists of orientation preserving involutions, in joint work with Bernard Maskit, we show that depending on the congruence class of n mod4, $\text{Möb}^+(n)$ has word length 2 or 3. As a consequence, $\text{Möb}^+(n)$ has commutator length one.

On the other hand, if the generating set consists of a single orientation preserving k-involution conjugacy class, in joint work with Karan Puri, we show that the word length of $\text{Möb}^+(n)$ is comparable to n. Here a k-involution is an involution with a fixed point set of codimension k. (Received August 27, 2010)

1067-30-507 **Christopher T. Sass*** (sass@math.utk.edu), 4614 Florence Rd., Knoxville, TN 37920, and **G. Brock Williams*** (brock.williams@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbo ck, TX 79409. *Circle Packings on Affine Tori.* Preliminary report.

In 1990 Beardon and Stephenson proved the existence and uniqueness of conformal structures on Riemann surfaces which support circle packings. A more general result for genus 1, the existence and uniqueness of circle packings on affine tori, will be presented. Face labels, a generalization of vertex labels, will be introduced, a new proof of the existence of vertex packing labels on conformal tori will be presented, and it will be shown that a modication of this argument establishes the existence of affine packing labels for combinatorial tori. We will also describe how Brooks' continued fraction parameter can be used to compute coordinates in the moduli space of conformal tori. (Received September 07, 2010)

1067-30-1085 **Mark W. Coffey*** (mcoffey@mines.edu), Department of Physics, 16th and Illinois Streets, Colorado School of Mines, Golden, CO 80401. *An effective asymptotic formula for the Stieltjes constants.*

The Stieltjes constants $\gamma_k(a)$ appear in the regular part of the Laurent expansion of the Hurwitz zeta function $\zeta(s,a)$ about its pole at $s = 1$ and the case $\gamma_k(1)$ [1] is of particular importance in analytic number theory. We present an asymptotic expression for $\gamma_k(a)$ for $k \gg 1$ that encapsulates both the leading rate of growth with k and the oscillations with k and a. This result is effective for computation, giving accurate values for both magnitude and sign for even moderate values of k. Comparison to some other work is made. Joint work with Charles Knessl.

[1] C. Knessl and M. W. Coffey, Math. Comp. (2010). (Received September 18, 2010)

1067-30-1367 **John Ryan*** (jryan@uark.edu), Department of Mathematics, University of Arkansas, Fayetteville, AR 72701. *On Dirac type operators.*

Lurking behind most Laplace operators is a first order Dirac operator. We shall introduce some examples in euclidean space, on the sphere and on spin manifolds. they include the non-linear p-Dirac operator. (Received September 20, 2010)

1067-30-1422 **Michael J Miller*** (millermj@mail.lemoyne.edu), Dept of Mathematics, Le Moyne College, Syracuse, NY 13214. *On a refinement of Sendov's conjecture (part 2).* Preliminary report.

Let β be a complex number of modulus at most 1. For those polynomials P with a root at β and all roots in the unit disk, define $r(\beta)$ to be the greatest possible distance between β and the closest root of the derivative P'. In this notation, Sendov's conjecture claims that $r(\beta) \le 1$.

We seek the greatest lower bound c of $\{(1 - r(\beta))/(\beta(1 - \beta)) : 0 < \beta < 1\}$. If Sendov's conjecture were true, then $c \ge 0$. It is known that $c \le 3/10$, and we have previously conjectured (see #1003-30-616) that $c = 3/10$; we show here that $c < 3/10$. (Received September 21, 2010)

1067-30-1445 **Gou Nakamura*** (gou@aitech.ac.jp), Center for General Education, Aichi Institute of Technology, Yakusa-cho, Toyota, 470-0392, Japan. *Compact Klein surfaces of genus 5 with extremal discs.*

A compact orientable or non-orientable hyperbolic surface S of genus g is called an extremal surface if it admits an extremal disc, a disc of the largest radius determined by g. Our problem is to determine extremal surfaces and to find how many extremal discs are embedded in them. If S is a compact Riemann surface of genus $g \geq 2$ or a compact Klein surface of genus $g = 3, 4$ or $g > 6$, then the problem was already solved. In this talk we shall discuss the extremal Klein surfaces of genus 5 and show that there are 3627 surfaces to be considered. (Received September 21, 2010)

1067-30-1537 **John J. George*** (jgeorge@math.fsu.edu), 1767 Hermitage Blvd Apt 5211, Tallahassee, FL 32308. *On Rankin's Uniformization of Algebraic Curves.*

We discuss Rankin's contributions to Whittaker's conjecture and review Rankin's uniformizations of certain algebraic curves by use of Schwarz triangle functions. We realize the fundamental groups for these curves as subgroups of the associated triangle groups. We use Whittaker's curve, as a special case, to exemplify the relationship between the monodromy and fundamental groups calculated by Whittaker and its triangle group. (Received September 21, 2010)

1067-30-1544 **David J Pinchbeck*** (dpinchbe@sjcme.edu), 278 White's Bridge Rd, Standish, ME 04084. *Riemann-Hilbert families of Schwarzian equations on the punctured torus.*

Given a representation of a monodromy group on a punctured Riemann surface, we define a "Riemann-Hilbert" correspondence with a matrix equation $F^{-1}\partial F = \Omega$ for a Fuchsian connection Ω associated to a vector bundle derived from the monodromy. We then associate to each such Ω a projective connection S on the surface so that the Fuchsian equation and the Schwarzian equation $y'' + \frac{1}{2}Sy = 0$ have the same monodromy. This results in a solution to the Riemann-Hilbert problem for Schwarzian equations. In this talk we apply the method to the once-punctured torus and analyze the resulting families of Schwarzians. (Received September 21, 2010)

1067-30-1563 **Stacey Muir*** (muellers2@scranton.edu), University of Scranton, Math Department, Scranton, PA 18510. *Construction of Complex-Valued Harmonic Mappings Convex in One or Every Direction.* Preliminary report.

We will discuss a new method for using a complex-valued convex analytic mapping on the unit disk to construct a complex-valued harmonic mapping that is convex in the direction of the imaginary axis. In addition, we will show a necessary and sufficient condition for the harmonic mapping to be convex is that the analytic mapping be direction convexity preserving. Connections to some harmonic mappings that have already been studied and new examples will also be given. (Received September 21, 2010)

1067-30-1591 **Matthew H Lochman*** (matthew.lochman@ttu.edu), Texas Tech University, Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409-1042, and **Roger W Barnard** and **Alexander Yu Solynin**. *Iceberg-type Problems: Estimating Hidden Parts of a Convex Continuum from the Visible Parts.*

We consider the compex plane $\mathbb{C}$ as a space filled by two different media, separated by the real axis $\mathbb{R}$. For a planar body E in $\mathbb{C}$, we discuss a problem of estimating characteristics of the "invisible" part, $E_- = E \setminus \{z : \Im z > 0\}$, from characteristics of the whole body E and its "visible" part, $E_+ = E \cap \{z : \Im z > 0\}$. The case for an arbitrary planar body E has been taken care of in a previous paper. In this paper, we find the maximal draft of E as a function of the logarithmic capacity of E and the area of E_+ under the more natural, yet also more difficult, assumption that E is convex. (Received September 21, 2010)

1067-30-1803 **Kourosh Tavakoli*** (ktavakoli@gc.cuny.edu). *Comparison of Conformal Metrics.*

In this talk, I introduce and compare some conformal metrics. The comparison leads to several interesting analytic and geometric results. (Received September 21, 2010)

1067-30-2305 **R. M. Ali** and **See Keong Lee*** (sklee@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia, and **Chandrashekar R.** and **K. G. Subramanian**. *Hypergeometric functions and subclasses of Harmonic Mappings.*

The seminal works of Clunie and Sheil-Small (1984) and Sheil-Small (1990) on harmonic mappings as generalizations of conformal mappings gave rise to investigation of properties of subclasses of harmonic univalent functions. Yalcin and Ož̈truk (2004) introduced a class $HP(\alpha)$ of functions harmonic and univalent in the unit disc. While connections between analytic univalent functions and hypergeometric functions have been well explored, only a few investigations on analogous connections between hypergeometric functions and harmonic mappings have taken place. Here sufficient conditions for a hypergeometric function and an integral operator related to hypergeometric function to be in the class $HP(\alpha)$ are obtained. Additional constraints give coefficient characterizations of the classes. (Received September 22, 2010)

1067-30-2386 **Hayley M Miles-Leighton*** (hmilesleighton@gmail.com). *The Links Between Smale's Mean Value Conjecture and Convergence.* Preliminary report.

Smale's Mean Value Conjecture (SMVC) states if f(z) is a complex valued polynomial and c is one of its critical points, then $|f(c)/c| \leq 1$. There has been some progress towards proving this conjecture, particularly in the past 10 years, but most have been better bounds on the original theorem that was proved by Steve Smale (the original theorem replaced 1 with 4). In this talk, I plan to introduce SMVC for the cubic polynomial case and explore the links between where these critical points satisfy SMVC and where they converge to the origin. To prove these links in full, I will explain a specific case of Beardon's Petal Theorem which will introduce the concepts of conjugacy as well as mappings by $1/z$ in the complex plane. (Received September 23, 2010)

31 ► Potential theory

1067-31-5 **T Toro*** (toro@math.washington.edu), Department of Mathematics, University of Washington, Box 354350, Seattle, WA 98195-4350. *Potential Theory meets Geometric Measure Theory.*

A central question in Potential Theory is the extent to which the geometry of a domain influences the boundary regularity of solutions to divergence form elliptic operators. To answer this question one studies the properties of the corresponding elliptic measure. On the other hand one of the central questions in Geometric Measure Theory (GMT) is the extent to which the regularity of a measure determines the geometry of its support. The goal of this talk is to present a few instances in which techniques from GMT and Harmonic Analysis come together to produce new results in both of these areas. (Received September 08, 2010)

1067-31-1062 **Ken McLaughlin*** (Ken.McLaughlin@gmail.com), Dept of math, Univ of az, Tucson, AZ 85719. *Asymptotic analysis of a random matrix model, and/or application of said asymptotic analysis.*

We will possibly consider a matrix model which is still solvable via Riemann Hilbert method but for which the limiting eigenvalue density is not uniquely determined by variational theory. Consequences will be discussed. (Received September 17, 2010)

1067-31-1108 **Matthew Badger*** (mbadger@math.washington.edu), Department of Mathematics, University of Washington, Box 354350, Seattle, WA 98195-4350. *Free boundary regularity for harmonic measure from two sides.*

We use tools from geometric measure theory to catalog fine behavior of harmonic measure (roughly the probability that a randomly drawn curve hits a subset of the boundary) in a nice class of domains $\Omega \subset \mathbb{R}^n$, $n \geq 3$. If the harmonic measures on the interior and exterior of the domain are mutually absolutely continuous and satisfy an additional mild hypothesis, then at every point the boundary looks locally like the zero set of a homogeneous harmonic polynomial. (Received September 18, 2010)

1067-31-2013 **Koushik Ramachandran*** (kramacha@math.purdue.edu), 2450 Sycamore lane, apt 27b, West Lafayette, IN 47906, and **Alexandre Eremenko** and **Svitlana Mayboroda**. *Asymptotics of positive harmonic functions on paraboloid-type regions.*

We obtain sharp asymptotic estimates at infinity for positive harmonic functions with zero data on the boundary in rough paraboloid-type regions. (Received September 22, 2010)

1067-31-2218 **Lucio M-G Prado*** (lprado@bmcc.cuny.edu), Department of Mathematics, BMCC -, The City University of New York, 199 Chambers Street, New York, NY 10007. *Classifying Homogeneous Trees and Lattices.*

An infinite graph can be classified according to its p-capacity in p-parabolic or p-hyperbolic. In particular, homogenous trees T_d and lattices $\mathbb{Z}^n$ can be classified by proving results similar to the Kevin-Nevanlinna-Royden theorem (criterion) in the continuous settings. Another approach for their classification, it is directly computing the p-capacity by using variational techniques.

In this talk, we will focus on both methods mentioned above for the complete classification of homogenous trees T_d. Finally, if time permits, a formula for the p-capacity of $\mathbb{Z}^n$ will be discussed.

(Received September 22, 2010)

32 ► Several complex variables and analytic spaces

1067-32-513 **Yaacov Kopeliovich*** (ykopeliovich@yahoo.com). *Thomae formula for general cyclic covers of $\mathbb{CP}^1$.*

Let X be a general cyclic cover of $\mathbb{CP}^1$ ramified at m points, $\lambda_1 ... \lambda_m$. we define a class of non positive divisors on X of degree $g-1$ supported in the pre images of the branch points on X, such that the Riemann theta function doesn't vanish on their image in $J(X)$. We generalize the results of [BR],[Na] and [EG] and prove that up to a certain determinant of the non standard periods of X, the value of the Riemann theta function at these divisors raised to a high enough power is a polynomial in the branch point of the curve X. Our approach is based on a refinement of Accola's results for 3 cyclic sheeted cover [Ac1] and a generalization of Nakayashiki's approach explained in [Na] for general cyclic covers. (Received September 08, 2010)

1067-32-538 **Serban Costea** and **Eric T. Sawyer** (sawyer@mcmaster.ca), McMaster University, Department of Mathematics and Statistics, 1280 Main Street West, Hamilton, ON L8S 4K1, Canada, and **Brett D. Wick*** (wick@math.gatech.edu), Georgia Institute of Technology, School of Mathematics, 686 Cherry Street, Atlanta, GA. *BMO Estimates for the $H^\infty(\mathbb{B}_n)$ Corona Problem.*

We study the $H^\infty(\mathbb{B}_n)$ Corona problem $\sum_{j=1}^N f_j g_j = h$ and show it is always possible to find solutions f that belong to $BMOA(\mathbb{B}_n)$ for any $n > 1$, including infinitely many generators N. Our method of proof is to solve $\overline{\partial}$-problems and to exploit the connection between BMO functions and Carleson measures for $H^2(\mathbb{B}_n)$. Key to this is the exact structure of the kernels that solve the $\overline{\partial}$ equation for $(0,q)$ forms, as well as new estimates for iterates of these operators. A generalization to multiplier algebras of Besov-Sobolev spaces is also given. (Received September 08, 2010)

1067-32-1554 **Jerry R. Muir, Jr.*** (muirj2@scranton.edu), Department of Mathematics, University of Scranton, Scranton, PA 18510. *The Roles Played by Order of Convexity or Starlikeness and the Bloch Condition in the Extension of Mappings from the Disk to the Ball.* Preliminary report.

Given f, a normalized ($f(0) = 0$, $f'(0) = 1$) locally univalent function defined on the open unit disk of $\mathbb{C}$, we consider the extension of f to the open unit ball of $\mathbb{C}^n$ given by $F(z) = (f(z_1) + G(\sqrt{f'(z_1)}\,\hat{z}), \sqrt{f'(z_1)}\,\hat{z})$, $\hat{z} = (z_2, \dots, z_n) \in \mathbb{C}^{n-1}$. Here G is a complex-valued holomorphic function defined on a ball in $\mathbb{C}^{n-1}$ of possibly infinite radius centered at 0 such that $G(0) = 0$ and $DG(0) = 0$. It is known that, if f is convex or starlike (univalent), then F inherits the same property when G is a homogeneous polynomial of degree 2 of sufficiently small norm. We consider what additional conditions on f will allow for G to have terms of degree greater than 2 in its expansion about 0 and have F still possess the relevant geometric property. (Received September 21, 2010)

1067-32-2098 **Mihaela B Vajiac*** (mbvajiac@chapman.edu), Chapman University, Schmid College of Science, One University Drive, Orange, CA 92866, and **Daniele C Struppa** (struppa@chapman.edu) and **Adrian I Vajiac** (avajiac@chapman.edu). *Multicomplex Spaces: Holomorphicity and Dolbeault Complexes.*

In this presentation we study regularity notions and properties of functions defined on multicomplex spaces, which are natural generalizations of the bicomplex numbers. In particular we will show how to construct an abstract Dolbeault complex in this case. Our results constitute a generalization of our previous research in this field (joint work with D.C. Struppa, and A. Vajiac). (Received September 22, 2010)

33 ► Special functions

1067-33-223 **David H Bailey** and **Jonathan M Borwein*** (jon.borwein@gmail.com). *Exploratory Experimentation and Computation.*

The mathematical research community is facing a great challenge to re-evaluate the role of proof in light of the growing power of cloud computing, of current computer systems, of modern mathematical computing packages, and of the growing capacity to data-mine on the Internet. Add to that the enormous complexity of many modern capstone results such as the Poincaré conjecture, Fermat's last theorem, and the Classification of finite simple groups.

As the need and prospects for inductive mathematics blossom, the requirement to ensure the role of proof is properly founded remains undiminished. I shall look at the philosophical context with examples and then offer some of five bench-marking examples of the opportunities and challenges we face.

This is based on joint work with David Bailey in a paper to appear in the Notices of the AMS `http://www.carma.newcastle.edu.au/~jb616/expexp.pdf`. (Received August 09, 2010)

1067-33-306 **Bruce C. Berndt** (`berndt@illinois.edu`), Dept. of Mathematics, University of Illinois, 1409 W. Green St., Urbana, IL 61801, and **Byungchan Kim*** (`bkim4@seoultech.ac.kr`), School of Liberal Arts, SeoulTech, 172 Gongreung 2 dong, Nowongu, Seoul, 139-743, South Korea. *Asymptotic Expansions of Certain Partial Theta Functions.*

In his second notebook, Ramanujan recorded an asymptotic expansion for the partial theta function

$$2\sum_{n=0}^{\infty}(-1)^n q^{n^2+n} = 2\sum_{n=0}^{\infty}(-1)^n\left(\frac{1-t}{1+t}\right)^{n^2+n} \sim 1+t+t^2+2t^3+5t^4+\cdots,$$

where $q=\frac{1-t}{1+t}\to 1^-$, or $t\to 0^+$. The first author established this asympotitic expansion giving an explicit representation for the coefficients in terms of Euler numbers. Later, R. Brent and W. Galway showed that the coefficients are positive integers, and, more recently, Richard Stanley found a combinatorial interpretation of these coefficients and so also established that they are positive integers.

The present authors examine the more general partial theta function

$$2\sum_{n=0}^{\infty}(-1)^n q^{n^2+bn} = 2\sum_{n=0}^{\infty}(-1)^n\left(\frac{1-t}{1+t}\right)^{n^2+bn} \sim \sum_{n=0}^{\infty}a_n t^n.$$

The coefficients a_n can be given in terms of Euler numbers and Hermite polynomials. Among other properties, the authors show, using a partial theta function identity of S. O. Warnaar, that if b is a positive integer, then the coefficients a_n are integers. (Received September 10, 2010)

1067-33-588 **Douglas Bowman**, **James G Mc Laughlin*** (`jmclaughl@wcupa.edu`) and **Nancy Wyshinski**. *Continued Fraction Proofs of m-versions of Some Identities of Rogers-Ramanujan-Slater Type.*

We derive two general transformations for certain basic hypergeometric series from the recurrence formulae for the partial numerators and denominators of two q-continued fractions previously investigated by the authors.

By then specializing certain free parameters in these transformations, and employing various identities of Rogers-Ramanujan type, we derive *m-versions* of these identities. Some of the identities thus found are new, and some have been derived previously by other authors, using different methods.

By applying certain transformations due to Watson, Heine and Ramanujan, we derive still more examples of such m-versions of Rogers-Ramanujan-type identities. (Received September 10, 2010)

1067-33-626 **Mourad E. H. Ismail*** (`mourad.eh.ismail@gmail.com`), Department of Mathematics, City U of Hong, Kong, Kowloon, Hong Kong. *Biorthogonal Rational Functions and R Fractions.*

We discuss some old and new biorthogonal rational functions related to the R_I and R_{II} fractions introduced by Ismail and Masson in Transactions Amer. Math. Soc. 346 (1994), pp. 63–116. These fractions extend the T-fractions. Some of the new functions come from the work by Ian Macdonald on Hecke algebras. We also indicate how the ${}_{10}\phi_9$ biorthogonal rational functions lead to an isochronous system of interacting particles. Some of the results presented are from joint papers in preparation with Dennis Stanton and with Mizan Rahman. (Received September 12, 2010)

1067-33-631 **Daniel Joseph Galiffa*** (`djg34@psu.edu`), Penn State Erie, The Behrend College, 4701 College Drive, Erie, PA 16563. *q-Orthogonal Polynomial Solutions to a Class of Differential-Difference Equations.* Preliminary report.

In this talk, we first briefly address how orthogonal polynomial solutions have been extracted from the differential-difference equation $\pi(x)DP_n(x)=(\alpha_n x+\beta_n)P_n(x)+\gamma_n P_{n-1}(x)$, where $\pi(x)$ is a polynomial of degree at most 2, with respect to the operators $D=d/dx$ and $D=D_q$. From there, we discuss the novel research conducted on this equation. Namely, we demonstrate how orthogonal polynomial solutions were obtained with respect to the operator $D=D_{q^{-1}}$. Among these solutions were the well-known and fully classified Al-Salam Carlitz II, discrete q-Hermite II, q-Laguerre and Stieltjes-Wigert polynomials. In addition, orthogonal polynomial solutions were obtained that, as far as we know, have not been fully characterized and require further analysis. (Received September 12, 2010)

1067-33-955 **Bruce C. Berndt*** (berndt@illinois.edu), Dept. of Mathematics, University of Illinois, 1409 W. Green St., Urbana, IL 61801. *Two Bessel Function Series in Ramanujan's Lost Notebook.*

On page 335 in his lost notebook, Ramanujan recorded without proofs two identities involving finite trigonometric sums and doubly infinite series of Bessel functions. The two identities are intimately connected with the classical *circle* and *divisor problems*, respectively. For each of Ramanujan's identities, there are three possible interpretations for the double series. In joint work with Sun Kim and Alexandru Zaharescu, the two identities have been proved in two of the three interpretations. In this talk, we concentrate on the historical background of the identities and the double Bessel function series identities when they are interpreted in one of two iterated methods of summation. In a sequel to this talk, Sun Kim will speak on the identities from a second viewpoint and also on new identities that arise from our methods. (Received September 16, 2010)

1067-33-1032 **Roger W. barnard*** (roger.w.barnard@ttu.edu). *"Application of special functions to disparate fields".* Preliminary report.

In this talk we will discuss several of our recent applications of Special Functions to disparate fields including complex analysis, statistics, ring theory, probability theory,and number theory, as time allows. (Received September 17, 2010)

1067-33-1452 **Dimitar K. Dimitrov** and **Alagacone Sri Ranga*** (ranga@ibilce.unesp.br), Universidade Estadual Paulista, Campus de Sao Jose do Rio Preto, S.J. do Rio Preto, SP, 15054-000, Brazil. *Szegő polynomials and para-orthogonal polynomials associated with hypergeometric functions.* Preliminary report.

With $\mathcal{R}e(b) > -1/2$ (also assuming $b \neq 0$), we consider the sequences of hypergeometric polynomials $\{R_m(b;z)\}$ and $\{S_m(b;z)\}$ given by $R_m(b;z) = {}_2F_1(-m, b; b+\bar{b}; 1-z)$ and $S_m(b;z) = {}_2F_1(-m, b+1; b+\bar{b}+1; 1-z)$. It was shown recently that $\{S_m(b;z)\}$ is the sequence of Szegő polynomials (i.e. orthogonal polynomials on the unit circle) with respect to the positive weight function $w(b;\theta) = e^{-\theta\,\mathcal{I}m(b)}[\sin(\theta/2)]^{2\mathcal{R}e(b)}$ and that $\{R_m(b;z)\}$ form a special sequence of para-orthogonal polynomials with respect to these Szegő polynomials. These results were proved using the theory of continued fractions and three term recurrence relations. From the theory of Szegő polynomials and para-orthogonal polynomials, the zeros of $S_m(b;z)$ are within the unit disk and the zeros of $R_m(b;z)$ are distinct and lie on the unit circle. The objective here is to consider further relations between these polynomials and their implications and also consider their connections to other known orthogonal polynomials in the literature. The real second order differential equations associated with the functions $g_m(x) = (4z)^{-m/2}R_m(z)$, where $2x = z^{1/2} + z^{-1/2}$, are also looked at. (Received September 21, 2010)

1067-33-1566 **Jennie D'Ambroise*** (jdambroi@morris.umn.edu), 600 East 4th St., Math Sci Div, Morris, MN 56267, and **Floyd L WIlliams**. *Parametric solution of certain nonlinear differential equations with applications in cosmology.*

We study a differential equation whose solution is written parametrically in terms of Weierstrass's $\wp(w), \sigma(w)$ and $\zeta(w)$ functions. By writing the equation in terms of some inverse functions we find that an 1865 formula, due to Weierstrass and published by Biermann, becomes relevant. Finally, we apply the result to some evolution equations in cosmology. This talk is a synopsis of joint work by the author with Floyd L. Williams. (Received September 21, 2010)

1067-33-1720 **Armin Straub*** (astraub@tulane.edu), 7532 Hampson St, New Orleans, LA 70118. *On the method of brackets.*

The method of brackets is a set of partially heuristic rules to evaluate definite integrals which has its origin in the negative dimensional integration method used in the context of integrals arising from Feynman diagrams. It was introduced by Ivan Gonzalez and Victor Moll. We describe the method, which may also be viewed as a multi-dimensional extension of Ramanujan's master theorem, and illustrate it with several examples. (Received September 21, 2010)

1067-33-1861 **Joel B. Geiger*** (jgeige1@math.lsu.edu), 16536 Ellis Ave., Baton Rouge, LA 70816, and **Milen T. Yakimov** (yakimov@math.lsu.edu). *Methods for constructing matrix-valued bispectral operators.*

In 1996 Bakalov, Horozov, and Yakimov presented a general framework for constructing solutions to the scalar-valued bispectral problem. We find noncommutative analogs of these results for matrix-valued bispectral functions. We explicitly construct large families of solutions based on rational Darboux transformations of generalized Bessel and Airy solutions, which include as special cases many previously known results. (Received September 22, 2010)

1067-33-2233 **Erin Beyerstedt**, Department of Mathematics, Tulane University, New Orleans, LA 70118, **Victor H Moll** (vhm@math.tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA , and **Xinyu Sun*** (xsun@xula.edu), Department of Mathematics, Xavier University of Louisiana, New Orleans, LA 70125. *Asymptotic p-adic methods.*

The p-adic valuation of many sequences appearing in Number Theory, Combinatorics and Special Functions have been analyzed by the authors. The common feature is an expansion of the form an series in which each term is a periodic function of period given by a power of the prime p. Examples include Stirling numbers and ASM (alternating sign matrices) numbers. These examples hint to a general procedure to be employed in sequences. (Received September 22, 2010)

1067-33-2430 **Andrei I. Davydychev*** (davyd@thep.physik.uni-mainz.de), Moscow State University, Russia, Moscow. *Geometrical approach to the evaluation of Feynman diagrams and its application to the epsilon-expansion* Preliminary report.

Departing from the standard Feynman parametric representation of multileg Feynman diagrams and using a number of transformations, one can translate these objects into geometrical language involving angles, (hyper-)volumes, etc. The connection of angular and kinematical variables is discussed, as well as the use of analytical continuation to get results valid in other regions of variables. For the dimensionally-regulated integrals, the epsilon-expansion of resulting hypergeometric functions is also described, inlcuding a recursive construction of higher terms and a connection to the multiple polylogarithms. (Partly based on work with Robert Delbourgo and Mikhail Yu. Kalmykov.) (Received September 30, 2010)

34 ► Ordinary differential equations

1067-34-20 **Toka Diagana*** (tokadiag@gmail.com), Howard University, Department of Mathematics, 2441 6th Street NW, Washington, DC 20059. *Existence of Pseudo Almost Automorphic Solutions to Some Second-Order Partial Evolution Equations.* Preliminary report.

Let $\mathbb{X}$ be a Banach space. This talk is concerned with the existence of pseudo almost automorphic solutions to the class of second-order partial evolution equations

$$\frac{d}{dt}\Big[Q'(t)+F(t,Q(t))\Big]=A(t)Q(t)+G(t,Q(t)),\quad t\in\mathbb{R}$$

where $A(t)$ for $t\in\mathbb{R}$ is a family of sectorial linear operators on $\mathbb{X}$ and $F,G:\mathbb{R}\times\mathbb{X}\mapsto\mathbb{X}$ are jointly continuous functions satsifying some additional conditions. Under some reasonable sufficient conditions, various existence results will be established. A few examples will also be discussed. (Received May 16, 2010)

1067-34-24 **Douglas R. Anderson*** (andersod@cord.edu), 901 8th Street S., Department of Mathematics, Moorhead, MN 56562. *Alternative Solutions of Inhomogeneous Second-Order Linear Dynamic Equations on Time Scales.*

We exhibit an alternative method for solving inhomogeneous second-order linear ordinary dynamic equations on time scales, based on reduction of order rather than variation of parameters. Our form extends recent (and long-standing) analysis on R to a new form for difference equations, quantum equations, and arbitrary dynamic equations on time scales. We apply our results to some nontrivial difference and q-difference equation examples. (Received May 27, 2010)

1067-34-92 **Joshua Mann***, Morehouse College, Atlanta, GA 30314, **Anthony Scrouse**, Morehouse College, Atlanta, GA 30314, and **Ronald E. Mickens**, Clark Atlanta University, Atlanta, GA 30314. *Preliminary Investigation on the Properties of the "Leah"-Cosine and -Sine Functions*†.

The fundamental trigonometric functions, sine and cosine, may be defined as solutions of ODE, $\ddot{x}+x=0$, with specific conditions

$$\cos t:\ddot{x}+x=0;\quad x(0)=1,\quad \dot{x}(0)=0,$$
$$\sin t:\ddot{x}+x=0;\quad x(0)=0,\quad \dot{x}(0)=1.$$

Likewise, special cases of the Jacobi elliptic functions are solutions to the following initial value problems

$$\mathrm{cn}(t):\ddot{x}+x^3=0;\quad x(0)=1,\quad \dot{x}(0)=0,$$
$$\mathrm{sn}(t):\ddot{x}+x^3=0;\quad x(0)=0,\quad \dot{x}(0)=1.$$

The current work introduces a new pair of functions defined by solutions to the nonlinear differential equations

$$\mathrm{Lcn}(t):\ddot{x}+x^{1/3}=0;\quad x(0)=1,\quad \dot{x}(0)=0,$$
$$\mathrm{Lsn}(t):\ddot{x}+x^{1/3}=0;\quad x(0)=0,\quad \dot{x}(0)=1.$$

We designate these solutions, respectively, the "Leah-cosine" (Lcn) and "Leah-sine" (Lsn) functions. Our presentation will discuss some of their elementary properties and list several open issues related to obtaining a fuller understanding of these functions.

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1067-34-287 **Maria Leite*** (mleite@ou.edu), **Barbara Benitez-Gucciardi**, **Suzanne Lenhart** and **Libin Rong**. *HIV-1 Model with latently infected cells and optimal drug treatment strategy.* Preliminary report.

In treatment of HIV is a common medical practice the use of highly active antiretroviral therapy, known as HAART. This therapy is often administered in the form of drug cocktails consisting of a protease inhibitor (PIs) and at least one or more reverse transcriptase inhibitors (RTIs). The HAART drugs have been highly successful in suppressing HIV in many patients and are widely available in the United States and Western Europe. However, their cost constitutes a problem not only in the underdeveloped but also in developed nations, where accordingly to UNAIDS only 7% of the infected population has access to HAART. Another challenge associate with the use of HAART is its high toxicity. This facts highlight the importance of investigate further drug dosage strategy. We will discuss results on optimal schedule treatment approaches for HIV-1. (Received August 16, 2010)

1067-34-379 **A Peterson*** (apeterso@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Asymptotic behavior of an n-th order sublinear dynamic equation.*

In this paper, we study the asymptotic behavior of the following n-th order sublinear dynamic equation

$$x^{\Delta^n}(t) + p(t)x^{\alpha}(t) = 0, \quad 0 < \alpha < 1,$$

where $p \geq 0$, on an isolated time scale $\mathbb{T}$, and α is a ratio of odd positive integers. As an application, we obtain

(i) when n is even, every solution $x(k)$ of the difference equation

$$\Delta^n x(k) + p(k)x^{\alpha}(k) = 0, \quad 0 < \alpha < 1,$$

where $p(k) \geq 0$, is oscillatory if and only if

$$\sum_{k=1}^{\infty} k^{\alpha(n-1)} p(k) = \infty.$$

(ii) when n is odd, every solution $x(k)$ of the difference equation is either oscillatory or $\lim_{k\to\infty} x(k) = 0$ if and only if the above sum diverges. (Received August 30, 2010)

1067-34-424 **Brittany C Stephenson*** (bcs173@msstate.edu), Department of Mathematics and Statistics, P.O. Drawer MA, Mississippi State, MS 39762, and **Emily K Poole** (ekpoole@uark.edu) and **Bonnie J Roberson** (bjr76@msstate.edu). *Weak Allee effect, grazing, and S-shaped bifurcation curves.*

We study a one-dimensional reaction-diffusion model arising in population dynamics where the growth rate is a weak Allee type. In particular, we consider the effects of grazing on the steady states and discuss the complete evolution of the bifurcation curve of positive solutions as the grazing parameter varies. We obtain our results via the quadrature method and Mathematica computations. In particular, we establish that the bifurcation curve is S-shaped for certain ranges of the grazing parameter. We also prove this occurrence of an S-shaped bifurcation curve analytically. (Received September 02, 2010)

1067-34-437 **Xueyan Sherry Liu*** (xueyan_liu@baylor.edu), Department of Mathematics, Baylor University, One Bear Place #97328, Waco, TX 76798-7328. *Nonlocal boundary value problems for nth order differential equations by solution matching.*

For the nth order differential equations $y^{(n)} = f(x, y, y', \cdots, y^{(n-1)})$, solutions satisfying nonlocal boundary conditions on $[a, b]$ are matched with solutions satisfying nonlocal boundary conditions on $[b, c]$ to obtain a unique solution satisfying nonlocal boundary conditions on $[a, c]$. Monotonicity conditions on f play a fundamental role in the matching. (Received September 03, 2010)

1067-34-555 **Jeffrey T Neugebauer*** (jeffrey_neugebauer@baylor.edu), Department of Mathematics, Baylor University, One Bear Place #97328, Waco, TX 76798-7328. *Comparison of Smallest Eigenvalues.*

The theory of u_0-positive operators with respect to a cone in a Banach space is applied to the linear differential equations $u^{(4)} + \lambda_1 p(x)u = 0$ and $u^{(4)} + \lambda_2 q(x)u = 0$, $0 \leq x \leq 1$, with each satisfying the boundary conditions $u(0) = u'(r) = u''(r) = u'''(1) = 0$, $0 < r < 1$. The existence of a smallest positive eigenvalue is established, and a comparison theorem for smallest positive eigenvalues is obtained. (Received September 09, 2010)

1067-34-702 **Reza R Ahangar*** (reza.ahangar@tamuk.edu), MSC 172, math Department, 700 University BLVD, Teaxs A & M University-Kingsville, Kingsville, Texas 78363.
Computational Approach to the Solution of Random Pertubed Logistic Model. Preliminary report.

Consider a classical stochastic differential equation dX(t)=X(t).(a-bX(t))+c.W(t)dW (1) (where X(t) is a solution and W(t) is a Brownian motion with a normal distribution of mean zero and standard deviation one. For constant real numbers a, b, and c, we define stochastic logistic differential equation(1). The solution to this logistic stochastic differential equation (1) can be introduced by Ito's integral calculus. Our goal is to estimate the solution using Riemann-Stieltjes integral where a function g(t)=W(t) does not have to be a differentiable function but it has to be a function of bounded variation. (Received September 13, 2010)

1067-34-751 **J. Diego Ramirez*** (dramzv@gmail.com), P.O. Box 43671, Lafayette, LA 70504, and **Aghalaya S. Vatsala**. *Existence of coupled minimal and maximal solutions of Fractional Periodic Boundary Value Problem via Initial Value Problem.* Preliminary report.

In this paper we develop monotone method for Caputo fractional differential equations of order q, $0 < q < 1$, with periodic boundary conditions. Our approach uses the corresponding initial value problem to develop natural monotone sequences or intertwined monotone sequences which converge monotonically and uniformly to coupled minimal and maximal periodic solutions. (Received September 14, 2010)

1067-34-778 **Eric R Kaufmann*** (erkaufmann@ualr.edu), Department of Mathematics and Statistics, 2801 S. University, Little Rock, AR 72204-1099. *A Fourth Order Boundary Value Problem with Multiple Resonance Conditions on a Time Scale.* Preliminary report.

We use a Leggett-Williams norm-type theorem for coincidences to show the existence of positive solutions for a fourth order multi-point boundary value with multiple resonance conditions. (Received September 14, 2010)

1067-34-779 **Zachary Denton*** (zhdenton@gmail.com), Department of Mathematics, University of Louisiana at Lafayette, P.O. Box 41010, Lafayette, LA 70504, and **Aghalaya Vatsala**.
Monotone Iterative Technique for Finite Systems of Nonlinear Fractional Differential Equations. Preliminary report.

Comparison results of the nonlinear scalar fractional differential equation of order q, 0<q<1, are presented and modified. Monotone method is developed for finite systems of fractional differential equations of order q, using coupled upper and lower solutions. (Received September 14, 2010)

1067-34-915 **Britney Hopkins*** (bhopkins3@uco.edu). *The existence of Multiple solutions for a fourth order nonhomogeneous boundary value problem.*

In this talk we consider the fourth order boundary problem, $u^{(4)} = \lambda h(t, u, u', u'', u''')$, $t \in (0, 1)$, subject to the boundary conditions, $u(0) = u''(0) = 0$, $u'(1) = a$, and $u'''(1) = -b$, where $\lambda, a, b \geq 0$, $a + b > 0$, and $h : [0, 1] \times [0, \infty) \times (-\infty, 0] \times [0, \infty) \times (-\infty, 0] \to [0, \infty)$ is continuous. By transforming the fourth order problem into a system of second order equations with homogeneous boundary conditions and then applying the Guo-Krasnosel'skii Fixed Point Theorem, we show the existence of at least three positive solutions. (Received September 16, 2010)

1067-34-919 **Ana Luz Vivas*** (alvivasm@nmsu.edu), 3500 Foothills Rd, J11, Las Cruces, NM 88011.
Dynamics of the SAIQR Influenza Model.

Mathematical models of disease transmission have been widely used and developed for well over a century. They have become standard "tools" in the study of the spread and control of communicable diseases like measles, tuberculosis, rubella, chicken pox and influenza. Influenza is one of the most common diseases affecting humans. SIR (Susceptible-Infectious-Recovered) epidemiological models or modifications have been used to model the dynamics of viral infections that provide permanent immunity after recovery. The inclusion of a class of individuals that are isolated after infection has gained increasing mathematical attention. The inclusion of a quarantine class Q gives SIQR epidemiological model the ability to support recurrent outbreaks. We introduce an extension of the SIQR model through the addition of a class A of asymptomatic individuals. The corresponding epidemiological model is referred as a SAIQR model. The mathematical and epidemiological properties of this model are studied: Existence and uniqueness of solutions, the basic reproduction number, the disease free and endemic equilibrium and conditions for the existence of periodic solutions via a Hopf bifurcations (in special cases). (Received September 16, 2010)

1067-34-940 **John R. Graef*** (john-graef@utc.edu), Department of Mathematics, The University of Tennessee at Chattanooga, Chattanooga, TN 37403, and **Lingju Kong** (lingju-kong@utc.edu) and **Qingkai Kong** (kong@math.niu.edu). *Uniqueness and parameter dependence of positive solutions for systems of fractional boundary value problems.*

Consider the fractional boundary value problem

$$-D^{\nu}_{0+}\boldsymbol{u}(t) = \Lambda f(t,\boldsymbol{u}),\ t\in(0,1),$$
$$\boldsymbol{u}^{(j)}(0)=0,\ j=0,\dots,n-2,\quad [D^{\alpha}_{0+}\boldsymbol{u}(t)]_{t=1}=0,$$

where $m\geq 1$ and $n\geq 3$ are integers, $n-1<\nu\leq n$, $1\leq\alpha\leq n-2$, $\boldsymbol{u}(t)=(u_1(t),\dots,u_m(t))^T$, $f(\boldsymbol{u})=(f_1(\boldsymbol{u}),\dots,f_m(\boldsymbol{u}))^T$, $\Lambda=\text{diag}\,[\lambda_1,\dots,\lambda_m]$, and D^{β}_{0+} is the Riemann-Liouville fractional derivative of order β. Criteria for the existence and uniqueness of positive solutions are obtained and the dependence of positive solutions on Λ is discussed. Some recent results from mixed monotone operator theory are used in the proofs. (Received September 16, 2010)

1067-34-1065 **Namjip Koo*** (njkoo@cnu.ac.kr), Department of Mathematics, Chungnam National University, Daejeon, 305-764, South Korea, and **Sung Kyu Choi**, Department of Mathematics, Chungnam National University, Daejeon, South Korea. *Dynamic inequalities of Bernoulli type.*

In this talk we briefly recall some general versions of Gronwall-Bellman inequality. Then we discuss Volterra discrete inequalities of Bernoulli type and extend these inequalities to dynamic inequalities on time scales. (Received September 17, 2010)

1067-34-1082 **Jinfeng Wang**, Harbin Normal University, Harbin, Peoples Rep of China, **Junping Shi*** (shij@math.wm.edu), College of William and Mary, Williamsburg, VA 23187, and **Junjie Wei**, Harbin Institute of Technology, Harbin, Peoples Rep of China. *Predator-prey model with strong Allee effect on prey population.*

Classical Rosenzweig-MacArthur predator-prey model assumes a logistic growth for the prey population. A strong Allee effect on the prey population introduces a population threshold. The dynamics of ODE model is completely classified, with phenomena of Hopf bifurcation, unique limit cycle, and heteroclinic loop. The dynamics, bifurcations, and a priori estimates for the PDE model will also be discussed. (Received September 18, 2010)

1067-34-1195 **Cornelis Van Der Mee*** (cornelis@krein.unica.it), Dip. Matematica e Informatica, Universita' di Cagliari, Viale Merello 92, 09123 Cagliari, CA, Italy, and **Francesco Demontis** (fdemontis@unica.it), Dip. Matematica e Informatica, Universita' di Cagliari, Viale Merello 92, 09123 Cagliari, CA, Italy. *Matrix exponential methods to derive exact solutions of nonlinear evolution equations.*

In this talk we derive explicit solutions of integrable nonlinear evolution equations (such as the KdV, mKdV, NLS, and sine-Gordon equations plus their matrix generalizations) by the inverse scattering transform method, where the inverse scattering problem is solved by the Marchenko method. Using a matrix triplet (A,B,C), the Marchenko integral kernel is written as $Ce^{-(x+y)A}e^{t\phi(A)}B$, with the analytic function $\phi(z)$ depending on the evolution equation. We also discuss transformations of the matrix triplets that leave the solutions invariant. (Received September 20, 2010)

1067-34-1260 **Stanca M. Ciupe*** (msc6503@louisiana.edu), 433 Maxim Doucet Hall, Lafayette, LA 70508, and **Patrick DeLeenheer** and **Thomas Kepler**. *Models of Antibody responses during HIV viral infections.*

During the course of an individual's infection with Human Immunodeficiency Virus (HIV), the virus population consists of a distribution of different variants, produced by mutation and selection. Consequently, the immune system attempts to build a response that is broad enough to handle the diversity of virus strains present. Biological experiments have shown that neutralizing antibodies fail to offer long-term protection because they are primarily strain-specific and lag behind viral evolution. We develop mathematical models of antibody mediated immune responses against HIV with an emphasis on their neutralizing and non-neutralizing activity. Analysis of the model helps us predict which factors (host or virus specific) influence the outcome of the infection. In particular, we determine the roles of competition and cross-reactivity between families of neutralizing antibodies in the presence and absence of virus evolution and their impact on disease prognosis. (Received September 20, 2010)

1067-34-1550 **Faina Berezovskaya*** (berezovskaya@howard.edu), Mathematics Department, Howard University, Washington, DC 20059. *Asymptote of orbits of a planar polynomial vector field with the fixed Newton polygon.*

The following statement has been proven.

Theorem. Consider a polynomial planar system on the Poincaré sphere that has an orbit $\{u_1(t), u_2(t)\}$, which tends to one of the following four equilibria $(m, l) = (0, 0), (0, \infty), (\infty, 0), (\infty, \infty)$ with a specified slope as $t \to \infty$ or $t \to -\infty$.

Then, in the case of a general position, only the following asymptotes of the orbit are possible: i) $u_1 \equiv 0$ and / or ii) $u_2 \equiv 0$ and / or iii) $u_2 = ku_1^\rho(1 + o(1))$, k=const$\neq 0$,
where $\rho > 0$ if $(m, l) = (0, 0)$ or $(m, l) = (\infty, \infty)$ and $\rho < 0$ if $(m, l) = (0, \infty)$ or $(m, l) = (\infty, 0)$.

The conditions of the general position are formulated, and the values of ρ and k are determined with help of the Newton Polygon of the system. (Received September 21, 2010)

1067-34-1586 **G. Edgar Parker*** (parkerge@jmu.edu), Department of Mathematics and Statistics, James Madison University, MSC 1911, Harrisonburg, VA 22807. *Boundary Points of $P_{n,m}$.* Preliminary report.

P, the set of projectively polynomial functions, is dense in $C[0, 1]$. On the other hand, $P_{n,m}$, the subset of P in which the projections can be made with a polynomial of degree n on $\mathbf{R}^m$, the elements with domain containing $[0, T]$ form a set that is locally compact in $C[0, T]$. This theorem is achieved through a representation in $\mathbf{R}^k$, where the co-ordinates of $\mathbf{R}^k$ come from the coefficients of the polynomial generators in each component and the components of the initial conditions. In this representation, unbounded sets may lead to functions which are limit points of subsets of $P_{n,m}$. This talk addresses some unsettled questions about these limit points. Examples are given that illustrate the plausibility of the questions. (Received September 21, 2010)

1067-34-1637 **Gaston M N'Guerekata*** (Gaston.N'Guerekata@morgan.edu), 1700 East Cold Spring Lane, Department of Mathematics, Morgan State University, Baltimore, MD 21251. *Stepanov-like almost automorphy for stochastic processes and applications to stochastic differential equations.*

We introduce the new concept of Stepanov-like almost automorphy, or S^2-almost automorphy for stocastic processes. We use the results obtained to investigate the existence and uniqueness of Stepanov-like almost automorphic mild solutions to a class of nonlinear stochastic differential equations in a real separable Hilbert space. The main results extend some known results in the case of square-mean almost automorphy (Received September 21, 2010)

1067-34-1654 **Barnabas Bede*** (bedeb@utpa.edu), 1201 West University, Edinburg, TX. *Existence and Characterization Theorems for Fuzzy Differential Equations.*

When modeling real-world phenomena, information available about a dynamical system is often uncertain or incomplete. The uncertainties are inherent and they are not always of statistical type, instead, they are epistemic, i.e., they may be due to the lack or imprecision of our knowledge about the data or even about the model. Such uncertainties are typically modeled by fuzzy data. It is a natural idea that the propagation of fuzzy uncertainties in a dynamical system can be modeled by Fuzzy Differential Equations. The talk will focus on fuzzy-valued functions and their derivatives and fuzzy differential equations. Local existence of two solutions and characterization theorems for fuzzy differential equations by ODEs will be discussed. (Received September 21, 2010)

1067-34-1663 **Samantha M. Tracht*** (samantha.tracht@gmail.com), Knoxville, TN, **Sara Y. Del Valle** (sdelvall@lanl.gov), Los Alamos, NM , and **Brian Edwards** (bke@lanl.gov), Los Alamos, NM. *Economic Analysis of the Use of Facemasks During Pandemic (H1N1) 2009.*

A large-scale pandemic could cause severe health, social, and economic impacts. The recent 2009 H1N1 pandemic confirmed the need for mitigation strategies that are cost-effective and easy to implement. In the early stages of a pandemic, as seen with pandemic (H1N1) 2009, vaccines and antivirals were non-existent or very limited, resulting in the need for non-pharmaceutical strategies to reduce the spread of disease and the economic impact. We construct and analyze a mathematical model for a population with three different age groups and assume that some individuals wear facemasks. We then quantify the impact facemasks have on the spread of pandemic (H1N1) 2009 and examine the cost effectiveness of using facemasks as a mitigation strategy. Our analyses show that an unmitigated pandemic could result in losses of nearly \$836 billion in the United States. Based on present value of future earnings (PV), hospital costs, and lost income estimates due to illness, this study estimates that the use of facemasks by 10%, 25%, and 50% of the population could reduce economic losses by \$479, \$571, and $573 billion respectively. The results show that facemasks if worn can significantly reduce the number of influenza cases as well as the economic losses due to a pandemic. (Received September 21, 2010)

1067-34-1902 **Donna Sue Stutson*** (dstutson@xula.edu), Xavier University of Louisiana, Mathematics Department, 1 Drexel Dr., New Orleans, LA 70125. *Some Results for Partial Fractional Differential Inequalities.*

In this talk, we will consider partial fractional differential inequalities of parabolic type using the Caputo ordinary derivative in t of order q, where $0 < q < 1$. We will recall a known comparison theorem for a Rieman-Liouville fractional differential inequality where the fractional derivative is if order q and $0 < q < 1$. Furthermore, we will develop a similar comparison theorem for partial fractional equations of parabolic type using the Caputo ordinary derivatives. (Received September 22, 2010)

1067-34-1932 **Roger Thelwell*** (thelwerj@jmu.edu), Dept. of Math and Stats, MSC 1911, James Madison University, Harrisonburg, VA 22807, and **Paul Warne**. *Cauchy-Kowalevski and Polynomial ODE.*

The Cauchy-Kowalevski Theorem is the main local existence and uniqueness theorem for analytic quasilinear partial differential equations (PDE) with Cauchy initial data. It began, however, as a statement about ordinary differential equations (ODE). We trace the tangled history of this idea, recover a clear *a priori* error bound, and apply the methods to the numerical solution of quasilinear ode. (Received September 22, 2010)

1067-34-1964 **William S. Janna*** (wsjanna@memphis.edu), Department of Mechanical Engineering, Memphis, TN 38152, and **Karyn M Bautista** (kmbtista@memphis.edu), Department of Mechanical Engineering, Memphis, TN 38152. *An Approximate Method for Obtaining a Polynomial Solution to the Problem of the Unsteady Velocity-Time History of Flow Startup in a Duct.*

An incompressible fluid is initially at rest in a duct. At some initial time, a valve is opened and due to external forces, the fluid accelerates to a steady state velocity. The mathematical model for finding the average steady state velocity is a nonlinear, first order, ordinary differential equation, which contains pressure, gravity, friction, and acceleration terms. The traditional solution method involves a linearization technique where the nonlinear term is assumed constant, and equal to its steady state value. A second solution method involves a numerical technique using a finite difference scheme. In this study, a third method of generating a velocity-time history in polynomial form is presented as an alternative technique. These methods are used to solve a specific example to obtain results that can then be compared. The indication is that the polynomial method compares favorably with the linearized solution, and so it can be used as an additional technique to describe the motion of an accelerating fluid. (Received September 22, 2010)

1067-34-1977 **Velasco-Hernandez** and **Maria Leite*** (mleite@ou.edu). *Influenza and SEIR model with isolation.*

We will present a model for the influenza epidemic in Mexico 2009 that describes the observed bi-modal pattern of the epidemic curve up to late August (before the onset of the expected winter epidemic). We will discuss the consequences of social isolation and other prophylactic measures that were implemented on the observed influenza temporal pattern. (Received September 22, 2010)

1067-34-2156 **Xinfu Chen** (xinfu@pitt.edu), 301 Thackeray Hall, Pittsburgh, PA 15260, and **Susmita Sadhu*** (sus38@pitt.edu), 301 Thackeray Hall, Pittsburgh, PA 15260. *Asymptotic Expansions Of Solutions Of An Inhomogeneous Equation.*

I will discuss a joint work with X. Chen on asymptotic behavior of solutions of

$$\varepsilon^2 u''(x) = u(x)(q(x) - u(x)), \quad \text{for x} \in [-1, 1],$$

where $\varepsilon > 0$ is a small parameter and q is a smooth, bounded function with minimum greater than or equal to 2. Under the boundary conditions $u(-1) = \alpha_-,\ u(1) = \alpha_+$, I will briefly derive asymptotic expansions of solutions that may have up to 3 critical points. The well known Carrier's equation

$$\varepsilon^2 y'' + 2(1 - x^2)y + y^2 = 1, \quad y(-1) = y(1) = 0$$

can be reduced to this form. If time permits, I will present some solutions of this boundary value problem and show that the conjectured formal asymptotics are correct up to $O(\varepsilon)$. (Received September 22, 2010)

1067-34-2230 **Justin R. Dunmyre***, 301 Thackeray Hall, University of Pittsburgh, Pittsburgh, PA 15260, **Christopher A. Del Negro**, PA , and **Jonathan E. Rubin**, PA. *Interactions of the CAN and NaP currents yield a novel bursting pattern in a model for a respiratory neuron.*

The preBötzinger complex (preBötC) of the mammalian brainstem is a neuronal network that generates the inspiratory phase of the respiratory cycle by maintaining a synchronous bursting rhythm. To investigate burst generation in preBötC neurons, previous modeling efforts have studied the individual role of either the persistent sodium (NaP) current or the calcium-activated non-specific cationic (CAN) current. However, both the NaP current and the CAN current are found in various strengths in virtually every preBötC neuron. Using tools from geometric singular perturbation theory, we present a model neuron that includes both the CAN and NaP currents, and explain how the interaction of these currents yields a new bursting pattern that has been observed in data, but not has not been seen in previous models of the preBötC. In our model, the mechanisms underlying the CAN and NaP currents evolve on a slower timescale than the rest of the system, and this fact is critical to our results. (Received September 22, 2010)

1067-34-2250 **Elizabeth Catsimanes*** (esc39500@ucmo.edu), Department of Math. and Computer Science, University of Central Missouri, Warrensburg, MO 64093. *Asymptotic Behavior for Systems of Nonlinear Differential Equations.*

In this talk the asymptotic behavior of solutions for a class of systems of nonlinear differential equations is discussed. Results of asymptotic behavior, continuability, and boundedness of solutions are obtained under natural assumptions. (Received September 22, 2010)

1067-34-2262 **Aaron T Welters*** (awelters@math.uci.edu), Department of Mathematics, University of California at Irvine, Irvine, CA 92697. *Perturbation Analysis of Slow Waves for Periodic Differential-Algebraic Systems of Definite Type.* Preliminary report.

In this talk we consider linear periodic differential-algebraic equations (DAEs) with properly stated leading term which are index-1 tractable such that the DAEs depend analytically on a parameter. In particular, we extend the results of M. G. Kreĭn and G. Ja. Ljubarskiĭ [*Amer. Math. Soc. Transl. (2) Vol. 89 (1970), pp. 1–28*] to linear periodic DAEs of definite type and study the analytic properties of the Bloch-Floquet multipliers for the system as function of the perturbation parameter.

The focus of this talk will be the connection between a non-diagonalizable Jordan normal form of the monodromy matrix for the reduced differential system associated with the DAEs and the occurrence of slow Bloch-Floquet waves/solutions for the periodic DAEs.

We conclude the talk with an application of this theory to the study of slow light in photonic crystals [A. Figotin and I. Vitebskiy, *Slow Light in Photonic Crystals*, Waves Random Complex Media, 16 (2006), pp. 293–382]. (Received September 22, 2010)

1067-34-2383 **Seshadev Padhi*** (ses_2312@yahoo.co.in), Dept of Appl Math, Birla Institute of Technology, Mesra, Ranchi, 835215, India, **Julio G Dix** (jd01@txstate.edu), Department of Mathematics, Texas state University- san Marcos, San Marcos, TX TX78666-46, and **Smita Pati** (spatimath@yahoo.co.in), Dept of Applied Mathematics, Birla Institute of Technology, Mesra, Ranchi, 835215, India. *Global Attractivity of Periodic Solutions of First Order Delay Differential Equations with Applications in Population Dynamics.*

In this paper, we obtain a new sufficient condition for the global attractivity of solution of the delay differential equation $x'(t)+p(t)x(t-\tau)=0,\ t\geq 0$ and $\tau>0$ is a constant. Further, the result have been applied to different mathematical models arising in ecology. (Received September 23, 2010)

1067-34-2389 **Seshadev Padhi*** (ses_2312@yahoo.co.in), Dept of Appl Math, Birla Institute of Technology, Mesra, Ranchi, 835215, India. *Existence of positive solutions of a first order dynamic equations on time scales.*

This paper is concerned with the existence of three positive T-periodic solutions of the first order functional differential equations of the form

$$x^{\Delta}(t)=a(t)x(\sigma(t))-\lambda b(t)f(t,x(h(t)))),$$

where $a(t),b(t)$ and $\tau(t)$ are positive T-periodic functions, and λ is a positive parameter. Leggett-Williams multiple fixed point theorem has been used to prove our results. Our results extend and improve some results in the literature. (Received September 23, 2010)

1067-34-2412 **Zhivko S Athanassov*** (zhivko@math.bas.bg), G. Bonchev Str. 8, 1113 Sofia, Bulgaria. *On Ordinary Differential Equations with Discontinuous Right Sides.* Preliminary report.

Contributions to the theory of ordinary differential equations with discontinuous right sides were made as early as the late twenties (M. Nagumo (1927) and A. Rosenthal (1929)). In 1967 V. Matrosov summarized much of what has been done in the area of such equations with special emphasis on the quasisolution of T. Wazewski introduced in 1963. In this talk we define generalized quasisolutions and discuss certain of their properties, including necessary and sufficient conditions for the existence of a generalized quasisolution of the system dx/dt = f(t,x). We discuss also the existance of periodic generalized quasisolutions of the system du/dt = v, dv/dt = -f(u,v)u - g(u), where f and g are measurable bounded functions. (Received September 23, 2010)

35 ► Partial differential equations

1067-35-57 **Armin Schikorra*** (schikorra@instmath.rwth-aachen.de), Institut für Mathematik, RWTH Aachen, Templergraben 55, 52062 Aachen, NRW, Germany. *Regularity of n/2-harmonic maps into spheres.*

We prove Hoelder continuity for $n/2$-harmonic maps from subsets of $\mathbb{R}^n$ into a sphere. This extends a recent one-dimensional result by F. Da Lio and T. Riviere to arbitrary dimensions. The proof relies on compensation effects which we quantify adapting an approach for Wente's inequality by L. Tartar, instead of Besov-space arguments which were used in the one-dimensional case. Moreover, fractional analogues of Hodge decomposition and higher order Poincare inequalities as well as several localization effects for nonlocal operators similar to the fractional laplacian are developed and applied. (Received July 02, 2010)

1067-35-75 **Ronald E. Mickens*** (rohrs@math.gatech.edu), Clark Atlanta University, Physics Department, Atlanta, GA 30314. *Exact Discretization of Linearized Euler Equations in One Space Dimension.*

The one-space dimension, linearized Euler equations provide an excellent mathematical model for the testing of novel finite difference schemes[1] which may then be applied to more complex partial differential equations arising in acoustic propagation. A major feature of the linearized Euler equations is that their exact general solution is known. Our goal is to determine a corresponding exact finite difference scheme for the original PDE's. This is done by using the linear nature of the equations and the fact that the coefficients are constant. A consequence of these properties is that the "operator equation" for this problem can be factored. Thus by a proper selection of the partial difference operators the required exact discretization can be calculated. The basis of these results follow from the transformation of two first-order PDE's to a single second-order PDE.

References

1. John W. Goodrich, "Application of a New High Order Finite Difference Scheme to Acoustic Propagation with the Linearized Euler Equation," NASA Technical Memorandum 106454 (Lewis Research Center; Cleveland, OH; 1993).

2. R. E. Mickens, *Nonstandard Finite Difference Models for Differential Equations* (World Scientific, Singapore, 1994). (Received July 14, 2010)

1067-35-78 **J. Nathan Kutz*** (kutz@amath.washington.edu), Applied Mathematics, University of Washington, Box 352420, Seattle, WA 98195-2420. *Proper Orthogonal Decomposition for Characterizing Nonlinear Wave Dynamics in Mode-Locked Lasers.*

Dimensionality reduction provides an important theoretical framework for characterizing the underlying dynamics and bifurcations in many nonlinear wave systems. The method of proper orthogonal decomposition (POD), or principal component analysis, is used here to demonstrate that low-dimensional systems generated by a POD analysis provides an excellent framework for characterizing the bifurcation behavior in mode-locked laser systems. More generally, the POD is shown to be an excellent dimensionality reduction technique for both Hamiltonian and dissipative nonlinear wave equations. (Received July 17, 2010)

1067-35-82 **Petronela Radu*** (pradu@math.unl.edu), 203 Avery Hall, Lincoln, NE 68588, **Grozdena Todorova**, Knoxville, and **Borislav Yordanov**. *The Diffusion Phenomenon and Decay Rates for Hyperbolic Equations with Damping.*

In this talk I will present an abstract version of the "strong" diffusion phenomenon which shows that the norm of the difference between the solution of the damped hyperbolic equation and the corresponding parabolic equation decays faster than the norm of each of the solutions, when the initial data is suitably chosen. We employ these results to transfer information on the asymptotic behavior between the heat and the damped wave equation when the elliptic operator has unbounded space dependent coefficients. (Received July 20, 2010)

1067-35-83 **Petronela Radu*** (pradu@math.unl.edu), Lincoln, NE 68588. *Local existence of strong solutions for semilinear wave equation with source and damping type interactions.*

This talk will focus on a recent result on local existence of strong solutions for semilinear wave equations with power-like interior damping and source terms. A long standing restriction imposed on the range of exponents allowed for the two nonlinearities is removed through a natural argument that uses the physics of the problem. The methods apply to the Cauchy problem as well as for initial boundary problems with homogeneous Dirichlet boundary conditions. (Received July 20, 2010)

1067-35-114 **Narayan Thapa*** (narayan.thapa@minotstateu.edu), Department of Mathematics and CS, Minot State University, Minot, ND 58707. *Parameter Estimation for Damped Sine-Gordon Equation with Neumann Boundary Condition.*

In this thesis we study an identification problem for physical parameters associated with damped sine-Gordon equation with Neumann boundary conditions. The existence, uniqueness, and continuous dependence of weak solution of sine-Gordon equations are established. The method of transposition is used to prove the Gâteaux differentiability of the solution map. The Gâteax differential of the solution map is characterized. The optimal parameters are established. Fŕechet differentiability of the cost functional J is established. Computational algorithm and numerical results are presented. (Received July 24, 2010)

1067-35-121 **George A. Anastassiou** (ganastss@memphis.edu), Department of Mathematical Sciences, Memphis, TN 38152, and **Razvan A. Mezei*** (rmezei@memphis.edu), Department of Mathematical Sciences, Memphis, TN 38152. *Quantitative Approximation by Fractional Smooth Poisson Cauchy Singular Operators.* Preliminary report.

In this article we study the very general fractional smooth Poisson Cauchy singular integral operators on the real line, regarding their convergence to the unit operator with fractional rates in the uniform norm. The related established inequalities involve the higher order moduli of smoothness of the associated right and left Caputo fractional derivatives of the engaged function. Furthermore we produce a fractional Voronovskaya type of result giving the fractional asymptotic expansion of the basic error of our approximation. We finish with applications. Our operators are not in general positive. (Received July 25, 2010)

1067-35-131 **Thomas Bellsky*** (bellskyt@msu.edu), Department of Mathematics, Michigan State University, A212 Wells Hall, East Lansing, MI 48824, and **Keith Promislow**. *Renormalization Group Method for Semi-Strong Pulse Interactions.*

This paper shows the nonlinear asymptotic stability in the semi-strong regime of two-pulse interactions in a general activator-inhibitor setting. We prove results for a general non-linearity that includes more specific equations such as the Gierer-Meinhardt model. In the semi-strong regime, the pulse amplitudes and speeds change as the pulse separation evolves on algebraically slow time scales. We use renormalization group techniques to prove the nonlinear asymptotic stability. We achieve this by examining the eigenvalue problem and proving semigroup estimates. (Received July 26, 2010)

1067-35-160 **Sarath Sasi*** (ss885@msstate.edu), **Eunkyoung Lee** and **Ratnasingham Shivaji**. *S-Shaped Bifurcation Curves in Ecosystems.*

We consider the existence of multiple positive solutions to the steady state reaction diffusion equation with Dirichlet boundary conditions of the form:

$$\begin{cases} -\Delta u = \lambda[u - \dfrac{u^2}{K} - c\dfrac{u^2}{1+u^2}], \quad x \in \Omega \\ \quad u = 0, \quad x \in \partial\Omega. \end{cases}$$

Here $\Delta u = div\big(\nabla u\big)$ is the Laplacian of u, $\frac{1}{\lambda}$ is the diffusion coefficient, K and c are positive constants and $\Omega \subset \mathbb{R}^N$ is a smooth bounded region with $\partial\Omega$ in C^2. This model describes the steady states of a logistic growth model with grazing in a spatially homogeneous ecosystem. It also describes the dynamics of the fish population with natural predation. In this paper we discuss the existence of multiple positive solutions leading to the occurrence of an S-shaped bifurcation curve. We prove our results by the method of sub-super solutions. (Received July 29, 2010)

1067-35-162 **Eunkyoung Lee**, **Lakshmi Sankar*** (lk154@msstate.edu) and **Ratnasingham Shivaji**.
Positive Solutions for Infinite Semipositone Problems on Exterior Domains.

We study positive radial solutions to the problem

$$\begin{cases} -\Delta u = \lambda K(|x|) f(u), & x \in \Omega \\ u = 0, & \text{if } |x| = r_0 \\ u \to 0 & \text{as } |x| \to \infty \end{cases} \tag{1}$$

where λ is a positive parameter, $\Delta u = \operatorname{div}\big(\nabla u\big)$ is the Laplacian of u, $\Omega = \{x \in \ \mathbb{R}^n, n > 2 |\, |x| > r_0\}$ is an exterior domain and $f : (0, \infty) \to \mathbb{R}$ belongs to a class of sublinear functions at ∞ such that they are continuous and $f(0^+) = \lim_{s \to 0^+} f(s) < 0$. In particular we also study infinite semipositone problems where $\lim_{s \to 0^+} f(s) = -\infty$. Here $K : [r_0, \infty) \to (0, \infty)$ belongs to a class of continuous functions such that $\lim_{r \to \infty} K(r) = 0$. We establish various existence results for such boundary value problems and also extend our results to classes of systems. We prove our results by the method of sub-super solutions. (Received July 28, 2010)

1067-35-165 **Katharine F Gurski*** (kgurski@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059, and **Stephen O'Sullivan**. *An Explicit Super-Time-Stepping Scheme for Non-Symmetric Parabolic Differential Equations.*

When a system of differential equations are dominated by a skew-symmetric component, the real eigenvalues are dominated by imaginary eigenvalues, and explicit numerical methods may suffer from a time step size that approaches zero in order to satisfy stability conditions. We present a new super-time-stepping method modeled on a Runge-Kutta scheme with multiplicative operator splitting which increases stability of the original super-time-stepping whenever the skew-symmetric term is nonzero. The new method is stable for skew symmetric dominated systems where the regular super-time-stepping scheme fails. This method is second order in time and the spatial order is determined by the user's choice of discretization scheme. We present a comparison between the two super-time-stepping methods to show the speed up available for any non-symmetric system using the nearly symmetric Black-Scholes equation as an example. (Received July 28, 2010)

1067-35-171 **Eunkyung Ko*** (ek94@msstate.edu), 319 N.Jackson st 1A, Starkville, MS 39759, and **Eunkyoung Lee** (eunkyoung165@gmail.com) and **R. Shivaji** (shivaji@ra.msstate.edu).
A multiplicity result for a class of infinite positone problems.

We study positive solutions to the singular boundary value problem

$$\begin{cases} -\Delta_p u = \lambda \frac{f(u)}{u^\beta} & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

where $\Delta_p u = \operatorname{div}\,(|\nabla u|^{p-2} \nabla u)$, $p > 1, \lambda > 0, \beta \in (0,1)$ and Ω is a bounded domain in $\mathbb{R}^N, N \geq 1$. Here $f : [0, \infty) \to (0, \infty)$ is a continuous nondecreasing function such that $\lim_{u \to \infty} \frac{f(u)}{u^{\beta+p-1}} = 0$. We establish the existence of multiple positive solutions for certain range of λ when f satisfies certain additional assumptions. A simple model that will satisfy our hypotheses is $f(u) = e^{\frac{\alpha u}{\alpha + u}}$ for $\alpha \gg 1$. We also extend our results to classes of systems when the nonlinearities satisfy a combined sublinear condition at infinity. We prove our results by the method of sub-super solutions. (Received July 28, 2010)

1067-35-173 **Andrew K. Gillette*** (agillette@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712, and **Chandrajit Bajaj**. *Dual Interpolants for Finite Element Methods.*

A canonical methodology for the discretization of differential operators is provided by the theory of Discrete Exterior Calculus (DEC). While this approach recreates many well known finite element systems associated to objects in a simplicial mesh of the domain, it also suggests novel linear systems associated to objects from an orthogonal dual domain mesh. In particular, it highlights the need for vector interpolant functions defined over polygonal and polyhedral elements which conform to the deRham complex associated to the problem.

In this talk, we will introduce the basics of the DEC technique and demonstrate how a dual-based system can easily be derived from a combined DEC-deRham diagram. Additionally, we will present a procedure for the design of dual-based scalar and vector interpolants with an eye toward their use in creating a discrete Hodge star (a.k.a. "mass matrix") used to transfer data between the primal and dual domain meshes. We will conclude with some initial results on the robustness of finite element solutions computed by this approach. (Received July 28, 2010)

1067-35-254 **Pengfei Yao*** (pyao@crimson.ua.edu), Department of Mathematics, University of Alabama, Tuscaloosa, AL 35487, and **Shan Zhao** (szhao@bama.ua.edu), Department of Mathematics, University of Alabama, Tuscaloosa, AL 35487. *A new boundary closure scheme for the multiresolution time-domain(MRTD) calculations.*

A novel boundary closure treatment for the wavelet based multiresolution time-domain (MRTD) solution of Maxwell's equations will be introduced. The novel scheme is able to accommodate non-trivial boundary conditions such as the Robin condition or time dependent condition in MRTD analysis of wave scattering, radiation, and propagation problems. A matched interface and boundary (MIB) method is adopted for boundary extensions when computational values are required outside standard domain. A systematic procedure is proposed to update the time in the MRTD calculations by using a novel Runge-Kutta schemes so that an arbitrarily high order of convergence in both space and time could be realized. The propsed boundary treatment can also be applied to other high order finite-difference time-domain(FDTD) approaches, such as the dispersion-relation-preserving(DRP) method, in order to handle more complicated electromagnetic structures. (Received August 13, 2010)

1067-35-259 **Emily J Evans*** (montu@wpi.edu), WPI/ Math Department, 100 Institute Rd., Worcester, MA 01752. *A Finite Element Approach to C^β Extension using Prefractals.*

We extend a function u defined on a fractal set S which satisfies the Hölder estimate

$$|u(x) - u(y)| \leq C_0|x-y|^\beta$$

for all x, y on S, to a larger domain $\Omega \subseteq \mathbb{R}^2$. The extension function u^* is defined everywhere in Ω, is Hölder continuous everywhere in Ω, corresponds with u at every point on S and satisfies the estimate $|u^*|_{\overline{\Omega},\beta} \leq C\|u\|_{S,\beta}$ with a constant C independent of u. Our approach is different and more constructive then the standard approach and exploits both the self-similarity of the fractal as well as the iterative process used to define the fractal set. (Received August 13, 2010)

1067-35-261 **Nsoki Mavinga*** (mavinga@math.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627, and **M. N. Nkashama** (nkashama@math.uab.edu). *Steklov-Neumann Eigenproblems and Nonlinear Elliptic Equations with Nonlinear Boundary Conditions.*

We will present existence results for nonlinear elliptic equations with nonlinear boundary conditions. We introduce the notion of 'eigenvalue-lines' in the plane; these eigenvalue-lines join each Steklov eigenvalue to the first eigenvalue of the Neumann problem with homogeneous boundary condition. The nonlinearities involved asymptotically stay, in some sense, below the first eigenvalue-lines or in a quadrilateral region enclosed by two consecutive eigenvalue-lines. The proofs are based on variational methods. (Received August 14, 2010)

1067-35-282 **Michael Sever*** (sever@math.huji.ac.il), Department of Mathematics, The Hebrew University, Givat Ram, Jerusalem, Israel. *Systems of conservation or balance laws with Lorentz-rotation symmetry.*

We classify examples of systems of conservation/balance laws for which a priori estimates exist for solutions of Cauchy problems, and which admit Lorentz-rotation symmetries. The objective is to construct models of two-fluid, multifluid or magnetohydrodynamic flow with such properties. Then we discuss such models with Galilean-rotation symmetries by passage to the low-speed limit. (Received August 16, 2010)

1067-35-302 **Jerome Goddard II*** (jg440@msstate.edu), Department of Mathematics and Statistics, P.O. Drawer MA, Mississippi State, MS 39762, and **Eun Kyoung Lee** (eunkyoung165@gmail.com) and **Ratnasingham Shivaji** (shivaji@ra.msstate.edu). *Diffusive logistic equation with non-linear boundary conditions.*

We analyze the steady state solutions of a population model with diffusion and logistic growth, namely,

$$\begin{aligned} -\Delta u &= au - bu^2 - ch(x); \quad \Omega \\ \alpha(u)\frac{\partial u}{\partial \eta} &+ [1-\alpha(u)]\,u = 0; \quad \partial\Omega \end{aligned}$$

where Ω is a subset of $\mathbb{R}^n$ with $n \geq 1$, $a, b > 0$, $c \geq 0$, $\alpha(u) : \mathbb{R} \longrightarrow [0,1]$ is a non-decreasing smooth function, and $\frac{\partial u}{\partial \eta}$ is the outward normal derivative. In particular, our study is focused on a population living in a patch, Ω subset of $\mathbb{R}^n$ with $n \geq 1$, that satisfies a certain nonlinear boundary condition and on its survival when constant yield harvesting is introduced. Our existence results are established by the method of sub-super solutions. (Received August 18, 2010)

1067-35-320 **Andrew J. Bernoff*** (ajb@hmc.edu), Department of Mathematics, Harvey Mudd College, Claremont, CA 91711, and **Chad M. Topaz** (ctopaz@macalester.edu), Dept. of Mathematics, Statistics, and CS, Macalester College, St. Paul, MN 55105. *A Primer of Swarm Equilibria.*

We study equilibrium configurations of swarming biological organisms subject to exogenous and pairwise endogenous forces. Beginning with a discrete dynamical model, we derive a variational description of the continuum population density. Equilibrium solutions are extrema of an energy functional, and satisfy a Fredholm integral equation. We find conditions for the extrema to be local minimizers, global minimizers, and minimizers with respect to infinitesimal Lagrangian displacements of mass. In one spatial dimension, for a variety of exogenous forces, endogenous forces, and domain configurations, we find exact analytical expressions for the equilibria. These agree closely with numerical simulations of the underlying discrete model.The exact solutions provide a sampling of the wide variety of equilibrium configurations possible within our general swarm modeling framework. The equilibria typically are compactly supported and may contain δ-concentrations or jump discontinuities at the edge of the support. We apply our methods to a model of locust swarms, which are observed in nature to consist of a concentrated population on the ground separated from an airborne group. Our model can reproduce this configuration; quasi-two-dimensionality of the model plays a critical role. (Received August 20, 2010)

1067-35-342 **Drossos Gintides** and **Mourad Sini*** (mourad.sini@oeaw.ac.at), Altenbergerstrasse, 69, 4040 Linz, Austria. *Identification of interfaces using the pressure parts (or the shear parts) of the elastic waves.*

In this talk, we are concerned with the inverse scattering by interfaces for the linearized, homogeneous and isotropic elastic model. We are interested by detecting smooth interfaces from the knowledge of elastic far field patterns. We prove that the 'pressure' parts of the far field patterns over all directions of measurements corresponding to all 'pressure' (or all 'shear') incident plane waves are enough for the detection. We also establish that the shear parts of the far field patterns corresponding to all the 'shear' (or all 'pressure') incident waves are also enough. This shows that any of the two different types of waves is enough to detect interfaces at a fixed frequency. (Received August 25, 2010)

1067-35-366 **Ramjee P Sharma***, rsharma@math.okstate.edu, Atlanta, GA 30092, and **Jiahong Wu**, Stillwater, OK 74078. *New Numerical Results on the Surface Quasi-Geosgrophic Equations.* Preliminary report.

The question whether classical solutions of the surface quasi-geostrophic (SQG) equation can develop finite-time singularities remains open. We present new numerical computations of the solutions to the SQG equation corresponding to several classes of initial data previously proposed by Constantin, Majda and Tabak. By parallelizing the serial pseudo-spectral codes through slab decompositions and applying suitable filters, we are able to simulate these solutions with great precision and on large time intervals. These computations reveal detailed finite-time behavior, large-time asymptotics and key parameter dependence of the solutions and provide information for further investigations on the global regularity issue concerning the SQG equation. (Received August 27, 2010)

1067-35-388 **Alfonso Castro*** (castro@math.hmc.edu), Department of Mathematics, Harvey Mudd College, Claremont, CA 91711. *Semilinear wave equations with non-monotone nonlinearity.*

Recent results of the solvability of $u_{tt} - u_{xx} + g(u) = p(x,t), u(t+2\pi, x) = u(t,x), u(t,0) = u(t,\pi)$ for g asymptotically linear and non-monotone will be discussed. The main interest in this problem is the fact that 0 is an eigenvalue of infinite multiplicity which in included in the range of the derivative of g. In contrast with semilinear elliptic boundary value problems, we will show cases where the problem is not at resonance, g and p are smooth and yet the problem has no continuous solution. (Received August 31, 2010)

1067-35-406 **Lorena Bociu*** (lbociu2@math.unl.edu), University of Nebraska-Lincoln, Department of Mathematics, 238 Avery Hall, Lincoln, NE 68588, and **Jean-Paul Zolesio**. *Existence for a linearized steady-state fluid-nonlinear elasticity interaction.*

A linearized steady-state three-dimensional fluid-structure interaction is considered and its solvability is studied. The linearization that we work with has new features, including the presence of the curvature terms on the common interface. These new extra terms, coming from the geometrical aspect of the problem, are critical for a correct physical interpretation of the fluid-structure coupling. We prove that the linearized coupled system has unique solution. (Received September 01, 2010)

1067-35-414 **Loc Hoang Nguyen***, 155 S 1400 E Rm 233, Salt Lake City, UT 84112, and **Klaus Schmitt**, 155 E 1400 S Rm 233, Salt Lake City, UT 84112. *Boundary value problems for singular elliptic equations.*

We study the existence of positive solutions to singular elliptic boundary value problems involving the $p-$Laplace operator. We establish a sub-supersolution theorem and use an eigenfunction of the $p-$Laplacian to construct sub- and super-solutions. Our assumptions on the singular term are more relaxed than in some previous papers, even for the case $p = 2$, as we allow for non-monotone singular terms with blowup controlled by a power. We also allow for a parameter dependent term and study how its growth affects our existence result. (Received September 01, 2010)

1067-35-415 **Jonathan Ben-Artzi*** (yonib@math.brown.edu), Department of Mathematics, Box 1917, Brown University, Providence, RI 02912. *Instability of Nonmonotone Magnetic Equilibria of the Relativistic Vlasov-Maxwell System.*

We consider the question of linear instability of an equilibrium of the Relativistic Vlasov-Maxwell (RVM) System that has a strong magnetic field. Standard instability results deal with systems where there are fewer particles with higher energies. In this paper we extend those results to the class of equilibria for which the number of particles does not depend monotonically on the energy. Without the standard sign assumptions, the analysis becomes significantly more involved. (Received September 01, 2010)

1067-35-416 **Daniel Arrigo** and **Long H Le*** (longl@uca.edu), University of Central Arkansas, Department of Mathematics, Conway, AR 72035, and **Jason Torrence**. *Exact solutions for a class of 3D-ratholes in highly frictional granular solids.*

The governing equations for the stress field for Coulomb-Mohr granular solids are highly nonlinear and hence only a few analytical solutions are known. In the special case of highly frictional materials (where the internal angle of friction is ninety degrees), exact parametric solutions exist for axially symmetric ratholes in the form of wedges and cubic profiles. We will show that in the highly frictional case, these governing equations are in fact linearizable. In particular, we consider power law ratholes superimposed upon a wedge hopper base. (Received September 01, 2010)

1067-35-419 **Liping Liu*** (liulipinig@uh.edu), 4800 Calhoun Road, Engr. Bldg 1, Houston, TX 77030. *New optimal bounds for two-phase non-well-ordered composites.*

In this paper we define and calculate the moment tensors for inhomogeneous media. Using the comparison theorem we then derive bounds on the energy induced by the inhomogeneities. In particular, when specified to two-phase composites, we recover the classic Hashin-Shtrikman's bounds for well-ordered materials and obtain new bounds for non-well-ordered materials. (Received September 02, 2010)

1067-35-426 **Eric A Carlen** (carlen@math.rutgers.edu), Dep. of Math., Rutgers Univ., Piscataway, NJ 08854, and **Suleyman Ulusoy*** (SUlusoy@cscamm.umd.edu), CSCAMM, Univ. of Maryland, College Park, MD 20742. *Localization, Smoothness, and Convergence to Equilibrium for a Thin Film Equation.*

We investigate the long-time behavior of weak solutions to the thin-film type equation

$$v_t = (xv - vv_{xxx})_x,$$

which arises in the Hele-Shaw problem. We estimate the rate of convergence of solutions to the Smyth-Hill equilibrium solution, which has the form $\frac{1}{24}(C^2 - x^2)_+^2$, in the norm

$$|f|_{m,1}^2 = \int_R (1 + |x|^{2m})|f(x)|^2 dx + \int_R |f_x(x)|^2 dx.$$

We obtain exponential convergence in the $|\cdot|_{m,1}$ norm for all m with $1 \leq m < 2$, thus obtaining rates of convergence in norms measuring both smoothness and localization. The localization is the main novelty, and in fact, we show that there is a close connection between the localization bounds and the smoothness bounds: Convergence of second moments implies convergence in the H^1 Sobolev norm. We then use methods of optimal mass transportation to obtain the convergence of the required moments. We also use such methods to construct an appropriate class of weak solutions for which all of the estimates on which our convergence analysis depends may be rigorously derived. Though our main results on convergence can be stated without reference to optimal mass transportation, essential use of this theory is made throughout our analysis. (Received September 02, 2010)

1067-35-450 **Jaffar Ali*** (jahameed@fgcu.edu), 10501 FGCU Blvd. S, Fort Myers, FL 33965, and **Ratnasingham Shivaji**. *Positive Solutions for an Elliptic Bi-variate Reaction Systems with Combined Nonlinear Effects.*

Consider the system

$$\begin{aligned} -\Delta_p u &= \lambda f(v,w) && \text{in } \Omega \\ -\Delta_p v &= \lambda g(w,u) && \text{in } \Omega \\ -\Delta_p w &= \lambda h(u,v) && \text{in } \Omega \\ u = & \quad v = w = 0 && \text{on } \partial\Omega. \end{aligned}$$

where Δ is the Laplacian operator, λ is a non-negative parameter, Ω is a bounded domain in R^n with smooth boundary $\partial\Omega$ and $f, g, h \in C([0,\infty) \times [0,\infty))$. We prove existence and multiplicity for this system under some combined sub-linearity conditions. (Received September 04, 2010)

1067-35-463 **Yu-Jui Huang*** (jayhuang@umich.edu), 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109, and **Erhan Bayraktar** (erhan@umich.edu). *On the Multi-dimensional Controller-and-stopper Games.*

We consider a zero-sum stochastic differential controller-and-stopper game in which the state process is a controlled jump-diffusion evolving in a multi-dimensional Euclidean space. In this game, the controller affects both the drift and the volatility terms of the state process. Under appropriate conditions, we show that the lower value function of this game is a viscosity solution to an obstacle problem for a Hamilton-Jacobi-Bellman equation, by generalizing the weak dynamic programming principles introduced in Bouchard and Touzi (2010). (Received September 05, 2010)

1067-35-466 **Mimi Dai*** (mdai@slugmail.ucsc.edu), 828 Koshland Way, Santa Cruz, CA 95064, and **Jie Qing** and **Maria Schonbek**. *Norm inflation for incompressible magneto-hydrodynamic system in $\dot{B}_{\infty}^{-1,\infty}$.*

Based on the construction of Bourgain and Pavlović for Navier-Stokes equations, we demonstrate that the solutions to the Cauchy problem for the three dimensional incompressible magneto-hydrodynamics (MHD) system can develop different types of norm inflation in $\dot{B}_{\infty}^{-1,\infty}$. Particularly the magnetic field can develop norm inflation in short time even when the velocity remains small and vice verse. Another interesting case is that, even with zero initial velocity, the velocity field can develop norm inflation in short time. We constructed different initial data to obtain these results using plane waves. (Received September 05, 2010)

1067-35-479 **Alexander L Volberg*** (sashavolberg@yahoo.com), Dept of Math., MSU, East Lansing, MI 48824. *Weak and strong weighted norm of any Calderon–Zygmund operator are equivalent.*

In this joint paper with Carlos Perez and Sergei Treil we prove that the norm of any Calderon–Zygmund operator on a weighted space can be tested by its norm (and the norm of the adjoint operator) on characteristic functions of cubes. This is a T1 theorem in the presence of A2 weight. From this result we derive a corollary that the strong weighted and the weak weighted norms are "equivalent" for any Calderon–Zygmund operator. Based on our main result Tuomas Hytonen proved a so-called A2 conjecture. Jointly (Tuomas Hytonen, Carlos Perez, Sergei Treil, Alexander Volberg) we get yet another–may be a bit simpler–proof. (Received September 06, 2010)

1067-35-481 **Patrick D Shipman** and **Zhiying Sun*** (zhiyings@math.uci.edu), 21 California Ave, Apt 314, Irvine, CA 92612, and **Alan C Newell** and **Pennybacker F Mattew**. *Universality of Fibonacci Patterns.*

Pattern patterns, or phyllotaxis, the arrangements of phylla (flowers, leaves, bracts, florets) in the neighborhood of growth tips, have intrigued natural scientists for over four hundred years. Prominent amongst the observed features is the fact that phylla lie on families of alternately oriented spirals and that the numbers in these families belong to subsets of the integers defined by the Fibonacci rule $m_{j+1} = m_j + m_{j-1}$. The corresponding patterns, which we call Fibonacci patterns, are widespread and universal on plants. Unlike the vast majority of research focusing on discrete mechanisms, our goal is to stem from actual physical and biochemical mechanisms experienced by the plant, which are governed by continuous PDEs, and ask if any patternforming system which is dominated by quadratic nonlinearities and in which the pattern is laid down annulus-by-annulus, by a generative front, will lead to Fibonacci patterns. We have shown that the Fibonacci patterns are fixed-points, free energy minimizing solutions of the order-parameter equations arising from a wide class of pattern-forming PDEs, and that these Fibonacci patterns have certain universal features which resemble what is seen in plants. (Received September 06, 2010)

1067-35-511 **Gung-Min Gie*** (gungmin@ucr.edu), Department of Mathematics, University of California, Riverside, 900 University Ave., Riverside, CA 92521, **Makram Hamouda** (mahamoud@indiana.edu), ISCAM, Indiana University, Rawles Hall, 831 E. Third St., Bloomington, IN 47405, and **Roger Temam** (temam@indiana.edu), ISCAM, Indiana University, Rawles Hall, 831 E. Third St., Bloomington, IN 47405. *Asymptotic analysis of the linearized Navier-Stokes equations in a general domain.*

We study, in a curved bounded domain in $\mathbb{R}^3$ with a characteristic boundary, the asymptotic behavior of the linearized Navier-Stokes equations (LNSE) when the viscosity is small. Using the curvilinear system, we show that the solutions of the LNSE behave like the corresponding Euler solutions except in a thin region, near the boundary, where a certain heat solution is added as a corrector. (Received September 07, 2010)

1067-35-523 **Zhongwei Shen*** (zshen2@email.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Homogenization of Neumann Boundary Value Problems.* Preliminary report.

In this talk I will discuss my recent joint work with Carlos Kenig and Fanghua Lin on uniform estimates for a family of second order elliptic systems with rapidly osillating periodic coefficients. We consider the Neumann problem in $C^{1,\alpha}$ domains and establish the uniform boundary Lipschitz estimates. As a consequence we are able to solve the L^p Neumann problem for all $1 < p < \infty$ with uniform non-tangenatial maximal function estimates. (Received September 08, 2010)

1067-35-540 **Avner Peleg*** (apeleg@buffalo.edu), Department of Mathematics, State University of New York at Buffalo, Buffalo, NY 14260, and **Quan Nguyen**, Department of Mathematics, State University of New York at Buffalo, Buffalo, NY 14260. *Population dynamics models for pulse dynamics in broadband fiber optics communication systems.*

We investigate the effects of Raman and two-photon-absorption crosstalk on the dynamics of pulse amplitudes in silica glass and silicon broadband transmission systems employing encoding with the phase. For Raman crosstalk we find that the dynamics is described by an N-dimensional predator-prey model and show that stable transmission can be achieved by a proper choice of the frequency profile of linear amplifier gain. For two-photon-absorption crosstalk we show that the dynamics is described by an N-dimensional model for competing species. In the latter case we find the conditions for stable transmission for a 2-dimensional system. (Received September 08, 2010)

1067-35-548 **Jianxin Zhou*** (jzhou@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843, **Ziqing Xie**, College of Mathematics and Computer Sciences, Hunan Normal University, Changsha, Hunan 410081, Peoples Rep of China, and **Yongjun Yuan**, College of Mathematics and Computer Sciences, Hunan Normal University, Changsha, Hunan 410081, Peoples Rep of China. *On finding multiple solutions to a singularly perturbed Neumann problem.*

In this talk, a modified local minimax method with new strategies is presented to numerically solve for multiple positive solutions to a singularly perturbed Neumann problem. Algorithm convergence and other related properties are verified. Motivated and convinced by new numerical results, the critical perturbation value is analytically verified, which closes a gap left in the literature for estimating such a value. Some interesting numerical results are displayed by their mesh profiles to illustrate the theory and method. (Received September 09, 2010)

1067-35-551 **Jonatan Lenells*** (Jonatan_Lenells@baylor.edu), Baylor University, Department of Mathematics, One Bear Place 97328, Waco, TX 76706. *Boundary value problems for the stationary axisymmetric Einstein equations.*

Two of the most important solutions of the stationary axisymmetric Einstein equations are the Kerr black hole and the Neugebauer-Meinel disk. In this talk I will present exact solutions of a class of boundary value problems for the Einstein equations which combine the Kerr and Neugebauer-Meinel spacetimes. Thus, the presented solutions involve a disk of dust rotating uniformly around a central black hole. The solutions are given explicitly in terms of theta functions on a family of hyperelliptic Riemann surfaces of genus four. (Received September 09, 2010)

1067-35-571 **Y. Ohta***, Rokko, Kobe, 657-8501, Japan. *Dark and bright soliton solutions for coupled derivative nonlinear Schrödinger equation.*

Coupled derivative nonlinear Schrödinger equations of focusing and defocusing types are studied by using the direct method of soliton theory. The equations are transformed into bilinear form and the dark and bright soliton solutions are given in terms of determinants and Pfaffians. Interactions of these solitons are also discussed. (Received September 09, 2010)

1067-35-594 **Irena Lasiecka*** (il2v@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22901, and **Shitao Liu** (sl3fa@virginia.edu), Department of mathematics, University of Virginia, Charlottesville, VA 22901. *Recovering a source from the measurments of acceleration of wall vibrations in structural acoustic problems.*

The PDE model consists of wave equation coupled to plate equation with the coupling occuring at the interface-manifold of lower dimension.

The source is being reconstructed from the measurments of acceleration of elastic wall, the latter modeled by plate equation.

The measurments are taken on the interface- separating acoustic environment and the elastic wall.

Both uniqueness of reconstruction and stability estimates are established.

The proofs are based on recently developed Carleman's estimates applicable to Neumann unobserved boundaries along with sharp trace regularity results available for wave equations. (Received September 10, 2010)

1067-35-596 **Irena Lasiecka*** (il2v@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA , and **Philip Graber** (pjg9g@virginia.edu), Department of mathematics, University of Virginia, Charlottesville, VA 22901. *Generation of dynamical flow and long time behavior of solutions to wave equation with acoustic boundary conditions.*

Wave equation with nonlinear acoustic boundary conditions is considered. This particular model arises in the context of modeling acoustic pressure in a chamber equipped with porous walls. It is shown that the resulting coupled system generates a well-posed semiflow defined by a continuous semigroup acting on a finite energy space. This result dispels previous conjectures made in the literature which suggest a nonexistence of a semigroup associated with weak solutions.

In addition, long time behavior os solutions is discussed. Both strong and uniform stability are established under suitable geometric conditions. (Received September 10, 2010)

1067-35-599 **John Matthews*** (Matt-Matthews@utc.edu), 415 EMCS Building, Dept 6956, 615 McCallie Ave, Chattanooga, TN 37363, **Boris P. Belinskiy** (Boris-Belinskiy@utc.edu), 415 EMCS Building, Dept 6956, 615 McCallie Ave, Chattanooga, TN 37363, and **Sergei A Avdonin** (saavdonin@alaska.edu), Fairbanks, AK 99775. *A Dynamical Inverse Problem on a Metric Graph.*

We present an algorithm based on the Boundary Control method for reconstruction of the potential for the wave equation on a particular star-shaped graph. The practicality of the algorithm is demonstrated through a numerical implementation which recovers a variety of potentials. Together the algorithm and implementation provide a fundamental first step for reconstructing the potentials on a larger metric tree. (Received September 10, 2010)

1067-35-600 **Chaoqun Huang*** (huang65@math.purdue.edu), Department of Mathematics, Office 437, 150 North University Street, West Lafayette, IN 47906, and **Aaron Nung Kwan Yip**. *Bifurcation of Internal Transition Layers for Spatially Inhomogeneous reaction-diffusion equation.*

The connection between diffused and sharp interfacial problems in the variational setting are well developed to a large extent by means of Gamma-convergence and also purely analytical techniques such as asymptotic expansion and implicit function theorem. They work well for the case of global minimizers and non-degenerate critical points. This talk will describe some results which extend the above framework to analyze the degenerate case, in particular the bifurcation of diffused interface and its connection to sharp interfacial limit. Examples of such bifurcation phenomenon using bistable nonlinearity together with parameter dependent spatial inhomogeneity are provided. The appearance and disappearance of the multiple transition layer is analyzed as well. We treat the unbalanced and balanced settings separately due to the fact that in higher dimensions the motion law of the sharp interfaces differs significantly, as one is an algebraic equation while the other is a PDE involving the mean curvature of the interface. This is joint work with Aaron Yip. (Received September 10, 2010)

1067-35-601 **Christopher J Winfield*** (winfield@madscitech.org). *Local Solvability on $\mathbb{H}_1$: Non-homogeneous operators.* Preliminary report.

Local solvability and non-solvability are classified for certain operators which are left-invariant on the Heisenberg group $\mathbb{H}_1$ of order $n \geq 2$. For a large subclass of our operators, (non-) solvability is determined by the highest order terms in X and Y. We study operators which can be written in form of polynomials with constant coefficients

$$P(X,Y) = P_n(X,Y) + Q(X,Y).$$

Here P_n is a homogeneous polynomial of degree $n \geq 2$ in a certain broad (so-called "generic") class; Q is any such polynomial but of order less than n; and, X, Y are the vector fields $X = \partial_x$, $Y = \partial_y + x\partial_z$.

Our operators can be viewed as perturbations of operators whose ($\mathcal{C}^\infty$) solvability is already classified in the present representation: $P_n(X,Y)$ is locally solvable if and only if the adjoint operators of both $\ker P(\pm i\partial_t, t)$ contain only the zero function. The solvability in our more general class is examined via asymptotic estimates of solutions certain ode's with a large parameter, analytic extensions of such solutions and a classification of related scattering matrices. (Received September 10, 2010)

1067-35-604 **Razvan C Fetecau*** (van@math.sfu.ca), 8888 University Drive, Burnaby, BC V5A 1S6, Canada, and **Raluca Eftimie**, Hamilton, ON L8S 4K1, Canada. *Nonlocal PDE models for self-organization of biological groups.*

We introduce and study two new PDE models for the formation and movement of animal aggregations. The models extend the one-dimensional hyperbolic model from Eftimie et al., Bull. Math. Biol. 69 (5) [2007]. Their main novel approach concerns the turning rates of individuals, which are assumed to depend in a nonlocal fashion on the population density. Our first model assumes in addition that the nonlocal interactions between individuals can also influence the speed of the group members. We investigate the local/global existence and uniqueness of solutions and we illustrate numerically the various patterns displayed by the model: dispersive aggregations, finite-size groups and blow-up patterns. The second model extends the approach from Eftimie et al. [2007] to two dimensions. We show that the resulting integro-differential kinetic equation with nonlocal terms has a unique classical solution, globally in time. We also present numerical results to illustrate various types of group formation that we obtained with the new model: (i) swarms (aggregation into a group, with no preferred direction of motion), and (ii) parallel/translational motion in a preferred direction with (a) uniform spatial density and (b) aggregation into groups. (Received September 10, 2010)

1067-35-606 **Andrea Bertozzi** (bertozzi@math.ucla.edu), **John Garnett** (jbg@math.ucla.edu) and **Thomas Laurent*** (laurent@math.ucr.edu). *Characterization of radially symmetric finite time blowup in multidimensional aggregation equations.*

The aggregation equation

$$\frac{\partial \rho}{\partial t} + \operatorname{div}\,(\rho \vec{v}) = 0, \tag{1}$$

$$\vec{v} = -\nabla K * \rho \tag{2}$$

is a continuum models for interacting particle systems with attractive/repulsive pairwise interaction potential K. It arises in a number of models for biological aggregation as well as problems in materials science and granular media. The main phenomenon of interest is that, even with smooth initial data, the solutions can concentrate mass in finite time (i.e. a delta Dirac appears in the solution in finite time). We prove rigorous result explaining how and under which circumstances these finite time blowups happen in the case of radially symmetric solutions. (Received September 13, 2010)

1067-35-620 **Nancy Rodriguez*** (nrodriguez@math.ucla.edu), Department of Mathematics, UCLA, Room MS 7601, Math Sciences Bldg, Los Angeles, CA 90095. *Local Well-Posedness and Blow-up Results for an Aggregation Equations and Patlak-Keller-Segel Models with Degenerate Diffusion.*

Recently, there has been much interest in modeling the competition between a species' desire to aggregate and the desire for personal space, referred to as dispersal. Two mathematical systems which model this competition are aggregation diffusion equations and Patlak-Keller Segel models, originally developed to model chemotaxis. Although the research of these two models have evolved separately they model the same phenomena. Classically, in the PKS equation, aggregation is modeled via convolution with the Newtonian or Bessel potential. On the other hand, the aggregation equation has been studied with more regular kernels. Our work focuses on unifying and extending the well-posedness theory of these equations. In particular, we study the well-posedness of an aggregation equation with degenerate diffusion, to model over-crowding effects, where the aggregation is modeled via the convolution with potentials as singular as the Newtonian potential. We generalize the notion of criticality seen in the PKS model with power-law diffusion and we observe a similar critical mass phenomenon. In this talk I focus on the local well-posedness of weak solutions. Furthermore, I discuss some blow-up results for supercritical systems and for a subclass of critical systems with large enough mass. (Received September 11, 2010)

1067-35-638 **Patcharin Tragoonsirisak*** (tragoonsirisakp@fvsu.edu), Department of Mathematics and Computer Sci., Fort Valley State University, Fort Valley, GA 31030. *A quenching problem due to a concentrated nonlinear source in an infinite strip.*

This article studies in an infinite-strip, a semilinear parabolic first initial-boundary value problem with a concentrated nonlinear source. Criteria for global existence of the solution and for quenching are investigated. (Received September 12, 2010)

1067-35-667 **Giovanna Guidoboni*** (gguidobo@math.iupui.edu), 402 N. Blackford St., LD270, Indianapolis, IN 46202-3267. *Arterial blood flow modeling.*

We will present some new ideas related to the mathematical and numerical modeling of arterial blood flow. We will discuss the derivation of simplified closed effective models and the design of stable loosely-coupled numerical algorithms. 1) Standard one-dimensional models are obtained by averaging on the vessel cross-section, under the assumptions of cylindrical geometry and axially symmetric-flows. One-dimensional models are not closed: an ad hoc velocity profile needs to be prescribed to obtain a closed system. In this talk we will present a different approach based on multi-scale analysis which leads to reduced effective models that do not need any ad hoc closure assumption. 2) Loosely-coupled algorithms are based on the idea of splitting the original problem in a sequence of simpler sub-problems. Stability of loosely-coupled schemes is a critical issue in blood flow applications due to highly nonlinear interfacial coupling effects. In this talk, we will present a new type of loosely-coupled algorithm which does not suffer from the interfacial instabilities. The algorithm has been named kinematically-coupled scheme because of the crucial role played by the kinematic condition at the fluid-solid interface. (Received September 13, 2010)

1067-35-686 **John L Lewis*** (john@ms.uky.edu), Patterson Office Tower, Mathematics Deaprtment, University of Kentucky, Lexington, KY 40506. *Regularity and Free Boundary Regularity for the p-Laplace Operator in Reifenberg Flat and NTA Ahlfors Regular Domains.* Preliminary report.

We discuss boundary regularity for the gradient of a positive p harmonic function, u, vanishing on a portion of the boundary of a sufficiently flat Reifenberg or NTA Ahlfors regular domain. We also discuss a free boundary problem involving the gradient of u. Our theorems are similar to those of Kenig and Toro for the harmonic p = 2 case. This work is joint with Kaj Nystrom. (Received September 13, 2010)

1067-35-723 **Karima Khusnutdinova*** (K.Khusnutdinova@lboro.ac.uk), Department of Mathematical Sciences, Loughborough University, Loughborough, LE11 3TU, England, and **Galina Dreiden**, **Alexander Samsonov** and **Irina Semenova**. *On classical and radiating strain solitary waves in layered waveguides.*

We discuss our recent analytical, numerical and experimental studies of long nonlinear waves in layered elastic waveguides. The emphasis is on classical and radiating solitary waves. In particular, we study the scattering of a long longitudinal strain solitary wave in a split, symmetric layered bar, made of a hyperelastic (Murnaghan) material. The problem is reduced to finding a solution of a Boussinesq-type equation with piecewise-constant coefficients, subject to some continuity conditions across the jump. The developed approach is based on matching two asymptotic multiple-scale expansions, integrability theory of the leading order KdV equations by the Inverse Scattering Transform and some natural radiation conditions. We show that splitting of the layered structure induces a generation of a train of secondary solitary waves from a single incident soliton and, thus, can be used to detect the defect. The theory is supported by experiments, performed in the Ioffe Institute in St. Petersburg (Russia). Possible applications of the described phenomenon include introscopy of layered structures and seismology. (Received September 14, 2010)

1067-35-747 **Jaffar Ali**, **Ken Brown** and **Ratnasingham Shivaji*** (shivaji@ra.msstate.edu), Department of Mathematics/CCS, Mississippi State University, Mississippi State, MS 39762. *Positive solutions to nxn elliptic systems with combined nonlinear effects.*

We study the existence and multiplicity of positive solutions to $n \times n$ systems of the form

$$\begin{aligned} -\Delta u_1 &= \lambda f_1(u_2) && \text{in } \Omega \\ -\Delta u_2 &= \lambda f_2(u_3) && \text{in } \Omega \\ \vdots &= \vdots \\ -\Delta u_{n-1} &= \lambda f_{n-1}(u_n) && \text{in } \Omega \\ -\Delta u_n &= \lambda f_n(u_1) && \text{in } \Omega \\ u_1 = u_2 &= \cdots = u_n = 0 && \text{on } \partial\Omega. \end{aligned}$$

Here Δ is the Laplacian operator, λ is a non-negative parameter and Ω is a bounded domain in $\mathbb{R}^N$ with smooth boundary $\partial\Omega$. The nonlinearities $f_i \in C^1([0,\infty)),\ i \in \{1,2,\cdots,n\}$ are strictly increasing functions such that $f_i(0) \geq 0,\ i \in \{1,\cdots,l-1,l+1,\cdots,n\}$ and $f_l(0) > 0$ for some $l \in \{1,\cdots,n\}$ (positone systems), and satisfy a combined sublinear condition at ∞. We establish our results by the method of sub and supersolutions.

*Joint work with Jaffar Ali and Ken Brown. (Received September 14, 2010)

1067-35-753 **Roberto Triggiani*** (rt7u@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22904, and **Shitao Liu** (sl3fa@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22904. *Global uniqueness and stability in determining coefficients for a system of coupled Schrodinger equations.* Preliminary report.

We consider the inverse problem of determining 2 unknown coefficients for a system of two strongly coupled Schrodinger equations with magnetic potential with Neumann non-homogeneous boundary conditions from Dirichlet boundary measurements on an explicit portion of the boundary and over an arbitrarily short time interval. Key ingredient in the proofs is a sharp and very general Carleman estimate for Schrodinger equations from the author's joint work (2002). (Received September 14, 2010)

1067-35-756 **George Avalos*** (gavalos@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Concerning the uniform stabilization of fluid-structure interaction PDE models.*

In this talk we shall derive certain delicate decay rates for a partial differential equation (PDE) system which comprises (parabolic) Stokes fluid flow and a (hyperbolic) elastic structural equation. The appearance of such coupled PDE models in the literature is well-established, inasmuch as they mathematically govern many physical phenomena; e.g., the immersion of an elastic structure within a fluid. The coupling between the distinct hyperbolic and parabolic dynamics occurs at the boundary interface between the media. In previous work, we have established semigroup wellposedness for such dynamics, in part through a nonstandard elimination of the associated pressure variable. For this PDE model, we provide a uniform rational decay estimate for solutions corresponding to smooth initial data; viz., for initial data in the domain of the semigroup generator. (Received September 14, 2010)

1067-35-762 **Antonio Degasperis*** (antonio.degasperis@roma1.infn.it), Dipartimento di Fisica, Sapienza Universita', Ple Aldo Moro 2, 00185 Roma, Italy. *Spectral theory of nonlocal cross-interaction of two waves.*

The cross interaction of two quasi-monochromatic waves in quadratic media may be described by an integrable system of first order partial differential equations. The non-locality of the interaction makes this model peculiar as the corresponding evolution equation of the spectral data corresponding to its solutions turns out to be itself nonlinear in contrast with standard integrable models. Both continuum and discrete spectrum solutions are discussed and the one soliton behavior is displayed. (Received September 14, 2010)

1067-35-767 **Matthias Eller*** (mme4@georgetown.edu), Department of Mathematics, Georgetown University, Washington, DC 20057. *Shape optimization for hyperbolic boundary problems with conservative boundary conditions.*

A shape optimization problem for some hyperbolic systems with conservative boundary conditions is considered. The differentiability of a shape functional is established under minimal regularity assumptions on the data.

Examples are the wave equation with Neumann boundary conditions and Maxwell's equations with the perfect conductor condition. (Received September 14, 2010)

1067-35-772 **Roberto Triggiani*** (rt7u@virginia.edu), University of Virginia, Department of Mathematics, P. O. Box 400137, Charlottesville, VA 22904-4137. *Global uniqueness and stability in inverse problems for second order hyperbolic equations with a non-homogeneous Neumann boundary term.*

We provide a global uniqueness and stability result in determining, in one shot, both the damping coefficient and the potential coefficient of an inverse hyperbolic problem with non-homogeneous Neumann term, through the measurement of an additional Dirichlet boundary trace over an explicit portion of the boundary and over a close to optimal, computable time interval. Key ingredients of the proof from past joint work of the author include: (i) sharp and very general Carleman estimates for second order hyperbolic equations; (iii) a correspondingly implied Continuos Observability Inequality; (ii) Sharp/optimal interior and boundary regularity theory of second order hyperbolic equations with Neumann boundary datum. This is joint work with Shitao Liu, Uva. Relations between inverse problems and control theory problems will also be unveiled. (Received September 14, 2010)

1067-35-776 **Robert Stephen Cantrell*** (rsc@math.miami.edu), Department of Mathematics, The University of Miami, Coral Gables, FL 33124, and **Chris Cosner**, **Yuan Lou** and **Chao Xie**. *Random dispersal versus fitness-dependent dispersal.*

We discuss a quasi-linear spatially heterogeneous reaction-diffusion-advection model for competition of two biological species in a bounded habitat. The species are assumed to be ecologically identical but to employ different dispersal strategies. Species 1 disperses solely on the basis of diffusing randomly throughout the habitat. Species 2 supplements the random component of its motion by advecting up the gradient of fitness; i.e., the spatially dependent local per capita growth rate discounted by the population densities of the two species. Both species are subject to no-flux conditions at the boundary of the habitat. We examine the dynamics of this system as the diffusion and advection parameters vary and draw conclusions about the relative efficacy of the two dispersal strategies. (Received September 14, 2010)

1067-35-782 **George Avalos*** (gavalos@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Minimal Norm Control Asymptotics and Numerical Approximations for the Null Controllability of Non-Standard Parabolic-Like PDE Dynamics.*

Semidiscrete finite difference approximation schemes are presented for the null controllability of structurally damped plate equations. The key feature here is that the null controllers being approximated exhibit the asymptotics of the associated minimal energy function. We focus here upon the "nonspectral case"; i.e., the fourth-order elastic component of the dynamics does not necessarily obey hinged boundary conditions. (Received September 14, 2010)

1067-35-786 **Karen Yagdjian*** (yagdjian@utpa.edu), Department of Mathematics, University of Texas-Pan American, 1201 W. University Drive, Edinburg, TX 78541-2999. *On the global solutions of the Higgs boson equation.*

In this talk we discuss global in time solutions of the equation for the Higgs boson in the Minkowski and in the de Sitter spacetimes. We reveal some qualitative behavior of the global solutions. In particular, for the global solutions we formulate sufficient conditions for the existence of the zeros in the interior of the support of solutions and, consequently, for the creation of bubbles. (Received September 14, 2010)

1067-35-797 **Tadele Mengesha*** (mengesha@math.lsu.edu), Department of Mathematics, Louisiana State University, 303 Lockett Hall, Baton Rouge, LA 70803, and **Robert Lipton**, Department of Mathematics, Louisiana State University, 303 Lockett Hall, Baton Rouge, LA 70803. *Local representations of L^∞ norms for weakly convergent sequences of gradient fields.*

In this talk we discuss the asymptotic behaviour of the L^∞ norms of a weakly convergent sequence of gradient fields associated with the homogenization of second order divergence form pde with measurable coefficients. For general oscillatory coefficients we identify local representation formulas that provide upper bounds on the limit superior of L^∞ norms of gradient fields. The formulas are expressed in terms of the weak limit of the gradient fields and local corrector problems. For the special cases of the fine phase limits for layered microstructures and (for sufficiently smooth) periodic microsturctures we provide an explicit local formula for the limit of the L^∞ norms of the associated sequence of gradient fields. Local representation formulas for lower bounds are also obtained for fields corresponding to continuously graded periodic microstructures. (Received September 14, 2010)

1067-35-807 **Nathan L. Gibson*** (gibsonn@math.oregonstate.edu). *Electromagnetic Relaxation Time Distribution Inverse Problems in the Time-domain.*

We consider wide bandwidth electromagnetic pulse interrogation problems for the determination of dielectric response parameters in complex dispersive materials. We couple Maxwell's equations with an auxiliary ODE modeling dielectric polarization. A problem of particular interest is to identify parameters in a standard polarization model (e.g., Debye or Lorentz) using time-domain electric field data. A larger class of materials (e.g., anomalously dispersive media) can be represented by assuming distributions of parameters (e.g., relaxation times). We present results for an inverse problem for the relaxation time distribution based on a least squares cost functional and utilizing generalized Polynomial Chaos in the forward problem. (Received September 15, 2010)

1067-35-851 **Zhifu Xie*** (zxie@vsu.edu), Department of Mathematics & Computer Science, P.O. Box 9068, Virginia State University, Petersburg, VA. *Cross-diffusion induced Turing instability for a three species food chain model.* Preliminary report.

In a reaction-diffusion system, diffusion can induce the instability of a uniform equilibrium which is stable with respect to a constant perturbation, as shown by Turing in 1950s. We study a strongly coupled reaction-diffusion system describing three interacting species in a food chain model, where the third species preys on the second one and simultaneously the second species preys on the first one. We first show that the positive equilibrium solution is globally asymptotically stable for the corresponding ODE system. The positive equilibrium solution remains linearly stable for the reaction diffusion system without cross diffusion, hence it does not belong to the classical Turing instability scheme. But it becomes linearly unstable only when cross-diffusion also plays a role in the reaction-diffusion system, hence the instability is driven solely from the effect of cross diffusion. (Received September 15, 2010)

1067-35-852 **Daniel Y Toundykov*** (dtoundykov@math.unl.edu), Avery Hall 203, P.O. 880130, Lincoln, NE 68588. *Finite-dimensional attractor for a structural-acoustic system with a localized feedback control.*

A system of coupled hyperbolic PDE's will be considered, modeling an acoustic chamber (wave equation) with a flexible boundary wall (Berger's plate). The wall is subject to a damping mechanism distributed over the entire surface, while the acoustic component is only dissipated on a subset of the interior domain. Both PDE's are perturbed by critical source terms. Critical sources correspond to non-compact perturbations of the principal dynamics, and may prevent convergence of trajectories to a global attractor.

The restricted dissipation on the wave equation, in combination with the critical source, prevents the applicability of standard methods when studying long-term behavior of this model. I will highlight some of the established, as well as more recent techniques, whose combination helps verify that such a coupled system may possess a finite-dimensional global attractor.

This is a joint work with Francesca Bucci (The University of Firenze, Italy) (Received September 15, 2010)

1067-35-853 **Necibe Tuncer*** (tuncer@ufl.edu), 309 Little Hall, Department of Mathematics, Gainesville, FL 32611. *Finite element approximation of reaction diffusion systems on arbitrary surfaces.*

In this research we develop and analyze two numerical methods to approximate solutions of reaction diffusion systems defined on arbitrary surfaces. In particular, we are interested in reaction diffusion systems that models pattern formation on evolving surfaces. Such systems have numerous applications; examples include patterns on seashells and tropical fish, tumor growth and cell membrane deformation. The power of both of these numerical methods are that they are easy to implement, and all computations are done in logically rectangular coordinates. (Received September 15, 2010)

1067-35-869 **Harumi Hattori** and **Zheng Zhang*** (zzhang719@gmail.com), 18B Glenn St, Morgantown, WV 26505. *Explicit Solutions for Optimal Portfolio and Consumption with Transaction Costs.*

In this paper, we study optimal portfolio and consumption with transaction costs. Explicit solutions to the corresponding HJB equations governing the no-transaction regions are found for typical utility functions such as a power function, an exponential function, and a natural logarithm function. An interesting finding is that contrary to the previous belief, the value function is not homothetic. Numerical results and some analytical results for the transaction and no-transaction regions are provided based on the value function. No-transaction regions are no longer straight wedges but curved ones. We also consider the cases where jump processes are added. (Received September 15, 2010)

1067-35-883 **Nicholas M Ercolani*** (ercolani@math.arizona.edu), Department of Mathematics, The University of Arizona, 617 N. Santa Rita Ave. P.O. Box 210089, Tucson, AZ 85721-0089. *A Burgers model for striped pattern formation in the strong bending regime.*

We will present a model for the formation of defects in patterns that arise in 2D, spatially extended physical systems whose principal bifurcation is from spatial homogeneity to semi-discrete (”striped”) patterns. Our model stems from a variational extension of the Cross-Newell phase diffusion equation and incorporates persepctives from experiment (Rayleigh-Benard convection), simulation and analysis. The analysis takes advantage of a Cole-Hopf linearization for the variational equations and invites comparison to the known validity of the Burgers phase equation in 1D. (Received September 15, 2010)

1067-35-896 **Turker Ozsari*** (tozsari@dogus.edu.tr), Dogus Universitesi Matematik Bolumu, Acibadem Mah. Zeamet Sok. No: 21, 34722 Kadikoy, Istanbul, Turkey. *Open Loop Stabilization of Nonlinear Schrodinger Equation.*

In this paper, we study the open loop stabilization as well as the existence and regularity of solutions of the weakly damped defocusing semilinear Schrödinger equation with an inhomogeneous Dirichlet boundary control. First of all, we prove the global existence of weak solutions at the H^1-energy level together with the stabilization in the same sense. It is then deduced that the decay rate of the boundary data controls the decay rate of the solutions up to an exponential rate. Secondly, we prove some regularity and stabilization results for the smooth solutions in H^2-sense. The proof uses the direct multiplier method combined with monotonicity and compactness techniques. The result for the weak solutions is strong in the sense that it is independent of the dimension of the domain, the power of the nonlinearity, and the smallness of the initial data. However, the regularity and stabilization of smooth solutions are obtained only in low dimensions with small initial and boundary data. (Received September 22, 2010)

1067-35-934 **Weifu Fang** and **Suxing Zeng*** (suxing.zeng@wright.edu), Department of Mathematics and Statistics, Wright State University, Dayton, OH 45435. *Recovery of an Interface from Boundary Measurement in an Elliptic Differential Equation.*

We study the inverse problem of recovering an interior interface from a boundary measurement in an elliptic boundary value problem arising from a semiconductor transistor model. We set up a nonlinear least-squares formulation for solving the inverse problem, and establish the necessary derivatives with respect to the interface. We then propose both the Gauss-Newton iterative method and the conjugate gradient method for the least-squares problem, and present implementation of these methods using integral equations. (Received September 17, 2010)

1067-35-951 **Jerry L. Bona*** (bona@math.uic.edu), University of Illinois at Chicago, Dept. Mathematics, Statistics & Computer Sci., 851 S. Morgan Street, MC 249, Chicago, IL 60607. *Stability of Solitary-Wave Solutions of the Hirota-Satsuma Equation.*

The Hirota-Satsuma equation was originally derived as a model for small amplitude, long wavelength water waves. It has explicit solitary-wave solutions that have been know for several decades. However, the question of their stability has proven to be challenging owing in part to the non-local character of the equation.

Making use of recent theory of Iorio and Pilod showing this equation is well posed, the author in collaboration with Dider Pilod has obtained a nonlinear stability result for these solitary-wave solutions.

In addition to sketching the details of this theory, we will also comment on the relevance of the equation to the propagation of water waves. (Received September 16, 2010)

1067-35-956 **Jeffrey R. Anderson**, **Keng Deng** and **Zhihua Dong*** (zxd5200@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70503. *Global Solvability for the Heat Equation with Boundary Flux Governed By Nonlinear Memory.*

We introduce the study of global existence and blow-up in finite time for the heat equation with flux at the boundary governed by a nonlinear memory term. Via a simple transformation, the model may be written in a form which has been introduced in previous studies of tumor-induced angiogenesis. The present study is also in the spirit of extending work on models of the heat equation with local and nonlocal nonlinearities present in the boundary flux. (Received September 16, 2010)

1067-35-962 **Peter Constantin*** (const@math.uchicago.edu), Department of Mathematics, The University of Chicago, 5734 S. University Ave., Chicago, IL 60637, and **Weiran Sun**. *Existence, uniqueness and stability for some models of complex fluids.*

I will discuss global existence, uniqueness and stability for Oldroyd-B systems and related models. The models resemble non-local damped and driven 3D Euler equations with variable density. I will show uniqueness and stability in relatively low regularity, natural spaces. Both existence and uniqueness are proved using a mixture of Lagrangian and Eulerian methods. I will explain why purely Eulerian methods are not easy to use for uniqueness in these relatively low regularity spaces. (Received September 16, 2010)

1067-35-970 **Ryan Croke**, Department of Mathematics, Colorado State University, Fort Collins, CO 80523, **Matti J Lassas**, Department of Mathematics, University of Helsinki, Helsinki, Finland, **Jennifer L Mueller*** (mueller@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523, **Samuli Siltanen**, Department of Mathematics, University of Helsinki, Helsinki, Finland, and **Andreas Stahel**, Bern University of Applied Sciences, Bern, Switzerland. *Numerical solution of the Novikov-Veselov equation.*

The solution of the Novikov-Veselov (NV) equation by the inverse scattering method is proved with the support of numerical evidence. The NV equation is a (2+1)-dimensional nonlinear evolution equation that generalizes the (1+1)-dimensional KdV equation. Evolutions of solutions in a certain class are computed numerically both by the inverse scattering method and a finite difference discretization of the Novikov-Veselov equation. New soliton solutions are presented, and a variety of computed evolutions are shown. (Received September 17, 2010)

1067-35-990 **Peter D. Miller*** (millerpd@umich.edu), Dept. of Mathematics, University of Michigan, East Hall, 530 Church St., Ann Arbor, MI 48109. *The Benjamin-Ono Equation in the Zero-Dispersion Limit.*

The Benjamin-Ono equation is a model for several physical phenomena, including gravity-driven internal waves in certain density-stratified fluids. It has the features of being a nonlocal equation (the dispersion term involves the Hilbert transform of the disturbance profile) and also of having a Lax pair and an associated inverse-scattering algorithm for the solution of the Cauchy initial-value problem. We will review known phenomena associated with this equation in the limit when the dispersive effects are nominally small, and compare with the better-known Korteweg-de Vries equation. Then we will present a new result (joint with Zhengjie Xu) establishing the zero-dispersion limit of the solution of the Benjamin-Ono Cauchy problem for certain initial data, in the topology of weak convergence. Our methodology is a novel analogue of the Lax Levermore method in which the equilibrium measure is given more-or-less explicitly rather than via the solution of a variational problem. The proof relies on aspects of the method of moments from probability theory. (Received September 17, 2010)

1067-35-991 **Venky P Krishnan*** (venkyp.krishnan@gmail.com), University of Bridgeport, Department of Mathematics, 126 Park Avenue, Bridgeport, CT 06604, and **Eric Todd Quinto** (todd.quinto@tufts.edu), Tufts University, Department of Mathematics, 503 Boston Avenue, Medford, MA 02155. *Microlocal Aspects of Bistatic Synthetic Aperture Radar Imaging.*

In this article, we analyze the microlocal properties of the linearized forward scattering operator F and the reconstruction operator F^*F appearing in bistatic synthetic aperture radar imaging. In our model, the radar source and detector travel along a straight line at a fixed distance apart. We show that F is a Fourier integral operator (FIO), and we give the mapping properties of the projections from the canonical relation of F, showing that the right projection is a blow-down and the left projection is a fold. We then show that F^*F is a singular FIO belonging to the $I^{p,l}$ class with $p = 3$ and $l = 0$. (Received September 17, 2010)

1067-35-999 **X.J. Wang*** (xjwang08@vt.edu) and **Michael Renardy** (mrenardy@math.vt.edu). *Ideal Magnetohydrodynamics, Non-Newtonian fluids with infinite Weissenberg number and related issues.*

Magnetohydrodynamics(MHD) finds a wide range of industrial applications, from liquid metals to cosmic plasmas. Weak solutions of Ideal MHD, just like weak solutions of Euler equation, have been conjectured to be promising candidates for the rigorous mathematical description of general turbulence.

It is well known that non-Newtonian flows at high Weissenberg number present many challenges for mathematical analysis; even more so than Newtonian fluids at high Reynolds number, including flow instabilities, singular features along walls, separating streamlines, and numerical difficulties. The study of limiting equations,

in which the Weissenberg number is formally set to infinity, is a logical first step in gaining a partial understanding of the high Weissenberg number limit, analogous to the study of the Euler equations for the high Reynolds number limit.

Here we present a well-posedness result for the equations arising in the infinite Weissenberg number limit of the upper convected Maxwell fluids. It is interesting to see the obvious structural analogy between Ideal MHD and our problem. (Received September 17, 2010)

1067-35-1041 **Mohammad A. Rammaha*** (mrammaha1@math.unl.edu), Department of Mathematics, Lincoln, NE 68588-0130, and **Yanqiu Guo** (s-yguo2@math.unl.edu), Department of Mathematics, Lincoln, NE 68588-0130. *Global Well-posedness for Systems of Nonlinear Wave Equations with Supercritical Boundary and Interior Sources.*

In this talk, I will give detailed analysis of the global well-posedness of the following system of wave equations:

$$\begin{cases} u_{tt} - \Delta u + g_1(u_t) = f_1(u,v) & \text{in } \Omega \times (0,\infty) \\ v_{tt} - \Delta v + g_2(v_t) = f_2(u,v) & \text{in } \Omega \times (0,\infty) \end{cases}$$

with with Robin and Dirichlét boundary conditions on u and v, respectively. Complimenting the existing results in the literature where the exponents of sources are at most critical, here, the sources $f_1(u,v)$, $f_2(u,v)$ and $h(\gamma u)$ are allowed to have supercritical exponents. The terms $g_1(u_t)$ and $g_2(v_t)$ represent interior damping while $g(\gamma u_t)$ represents a boundary damping. Under some restrictions on the parameters in the system and with careful analysis involving the theory of monotone operators, we obtain several results on the existence of local solutions, global solutions, and uniqueness. In addition, we prove that weak solutions to the system blow up in finite time whenever the initial energy is negative and the exponent of each source term is more dominant than the exponents of the corresponding damping term. (Received September 17, 2010)

1067-35-1046 **Lokenath Debnath*** (debnathl@utpa.edu), 1201 W. University Drive, Edinburg, TX 78539. *Solutions of Fractional Order Partial Differential Equations.*

Some solutions of linear and nonlinear fractional order partial differential equations will be presented with examples and applications. Several special cases will be discussed. (Received September 17, 2010)

1067-35-1057 **Guenbo Hwang*** (ghwang@cems.uvm.edu), Department of Mathematics and Statistics, University of Vermont, Burlington, VT 05401, and **Triantaphyllos R Akylas** and **Jianke Yang**. *Linear Stability of Gap Solitons in One-dimensional Periodic Media.*

We study the linear stability of gap solitons in periodic media described by the nonlinear Schrödinger equation with a periodic potential. Motivated by our numerical evidence that the eigenvalue near band edges is indeed exponentially small, we use the exponential asymptotic method to calculate this small eigenvalue of the linear stability problem. By means of the exponential asymptotics, two branches of gap solitons bifurcate from band edges, referred to as on-site and off-site gap solitons. We show that on-site gap solitons are linearly stable while off-site gap solitons are unstable. In addition, we compare the analytical eigenvalue formulae with those obtained numerically. The comparisons show perfect agreement between the analytical results and the numerical values. (Received September 17, 2010)

1067-35-1072 **Guoping Zhang*** (hyzgp73@yahoo.com), 1700 E Cold Spring Ln, Baltimore, MD 21251. *Bifurcation problem of the discrete nonlinear Schrödinger equations with sign changing nonlinearity.* Preliminary report.

In this talk we will present our recent results on the bifurcation phenomenon of the discrete Schrödinger equation with unbounded potentials. For the case of self-focusing and defocusing nonlinearity all eigenvalues of Schrödinger operator are bifurcation points and our estimates near the bifurcation points are optimal for the linking solutions. For the case of sign changing nonlinearity we can only obtain the bifurcation estimate near the first eigenvalue of Schrödinger operator. (Received September 17, 2010)

1067-35-1086 **Claude Bardos** (claude.bardos@gmail.com), Laboratory J.L.Lions, University of Pierre and Marie Curie, 75013 Paris, France, and **Edriss S Titi*** (etiti@math.uci.edu), Dept. of Computer Science and Applied Math, The Weizmann Institute of Science, 76100 Rehovot, Israel. *On the Loss of Regularity for the Three-Dimensional Euler Equations.*

A basic example of shear flow was introduced by DiPerna and Majda to study the weak limit of oscillatory solutions of the Euler equations of incompressible ideal fluids. In particular, they proved by means of this example that weak limit of solutions of Euler equations may, in some cases, fail to be a solution of Euler equations. We use this shear flow example to provide non-generic, yet nontrivial, examples concerning the loss of smoothness of solutions of the three-dimensional Euler equations, for initial data that do not belong to $C^{1,\alpha}$.

Moreover, we show by means of this shear flow example the existence of weak solutions for the three-dimensional Euler equations with vorticity that is having a nontrivial density concentrated on non-smooth surface. This is very different from what has been proven for the two-dimensional Kelvin-Helmholtz problem where a minimal regularity implies the real analyticity of the interface.Eventually, we use this shear flow to provide explicit examples of non-regular solutions of the three-dimensional Euler equations that conserve the energy, an issue which is related to the Onsager conjecture. (Received September 18, 2010)

1067-35-1089 **Mircea Martin*** (mircea.martin@bakeru.edu), Department of Mathematics, Baker University, Baldwin City, KS 66006. *Generalized Cauchy-Pompeiu and Bochner-Martinelli-Koppelman Integral Representation Formulas.* Preliminary report.

We set up generalized Cauchy-Pompeiu and Bochner-Martinelli-Koppelman representation formulas for arbitrary pairs $(\mathfrak{D}, \Phi)$, where $\mathfrak{D}$ is a first-order homogeneous differential operator on $\mathbb{R}^n$ with coefficients in a Banach algebra $\mathfrak{A}$, and Φ is a smooth $\mathfrak{A}$-valued function on $\mathbb{R}^n \setminus \{0\}$ homogeneous of degree $1-n$, $n \geq 2$. Within our general framework we prove that the integral representation formulas include the expected components, as well as some remainders that are explicitly computed in terms of $\mathfrak{D}$ and Φ. As a consequence, we obtain necessary and sufficient conditions that ensure the existence of genuine Cauchy-Pompeiu or Bochner-Martinelli-Koppelman formulas for $(\mathfrak{D}, \Phi)$. These conditions prove valuable in investigating Dirac and Cauchy-Riemann operators. (Received September 18, 2010)

1067-35-1098 **Peter W Bates** and **Fengxin Chen*** (Fengxin.Chen@utsa.edu), Dept. of Mathematics, University of Texas at San Antonio, One UTSA Circle, San Antonio, TX 78249, and **Richard Lenski**. *Structure of Principal Eigenvectors and Genetic Diversity.*

The main concern of this paper is long-term genotypic diversity. Genotypes are represented as finite sequences $(s_1, s_2, \ldots, s_n)$, where the entries $\{s_i\}$ are drawn from a finite alphabet. The mutation matrix is given in terms of Hamming distances. It is proved that the long time behavior of solutions for a class of genotype evolution models is governed by the principal eigenvectors of the sum of the mutation and fitness matrices. It is proved that the components of principal eigenvectors are symmetric and monotonely decreasing in terms of Hamming distances whenever the fitness matrix has those properties. The principal eigenvectors corresponding to the fast and slow mutations are also studied. (Received September 18, 2010)

1067-35-1101 **Jerry L. Bona*** (bona@math.uic.edu), Dept. Mathematics, Statistics & Computer Sci., University of Illinois at Chicago, 851 S. Morgan Street MC 249, Chicago, IL 60607. *Initial-Boundary-Value Problems and Inverse Scattering Methods.* Preliminary report.

We will discuss using inverse-scattering methods in the solution of initial-boundary-value problems for nonlinear, dispersive wave equations. Recent work of H. Chen, A. Fokas, F. Gestezy and J. Lennels will be featured in the discussion. (Received September 18, 2010)

1067-35-1129 **Cody Pond*** (cpond@tulane.edu), Department of Mathematics, Tulane University, 6823 St. Charles Ave, New Orleans, LA 70118. *Lifespans for Effective Boundary Conditions.*

The problem of protecting a body from overheating with a thin coating of insulation arrises naturally in many settings. In aerospace applications the insulation may have anisotropic, or direction dependent, heat conduction properties. In this talk we will present new results on how scaling relationships between the thickness of the coating and the anisotropic properties of the insulation influence the effective boundary condition on the insulated body. In particular we show how the time interval during which the effective boundary is Neumann scales with the thickness and heat conduction properties of the insulation. (Received September 19, 2010)

1067-35-1130 **Wenxiong Chen*** (wchen@yu.edu), Department of Math, Yeshiva University, 2495 Amsterdam Avenue, New York, NY 10033, and **Congming Li**. *Symmetry of Solutions for Nonlinear Integral and PDE Systems.*

In this talk, I will introduce the integral form of the method of moving planes and its applications, mainly in establishing symmetry for solutions of integral equations and systems as well as PDEs due to the equivalences between the two. This method is quite different from the traditional ones for PDEs. Instead of using maximum principles, some global norms are estimated. It can be applied to obtain radial symmetry for positive solutions of the fully nonlinear integral systems involving Wolff potentials:

$$\begin{cases} u(x) = W_{\beta,\gamma}(v^q)(x), & x \in R^n; \\ v(x) = W_{\beta,\gamma}(u^p)(x), & x \in R^n; \end{cases} \tag{1}$$

where

$$W_{\beta,\gamma}(f)(x) = \int_0^\infty \left[\frac{\int_{B_t(x)} f(y)dy}{t^{n-\beta\gamma}} \right]^{\frac{1}{\gamma-1}} \frac{dt}{t}.$$

In a special case when $\beta = \frac{\alpha}{2}$ and $\gamma = 2$, system (1) reduces to an integral system with Reisz potentials, which is equivalent to a system of PDEs. In particular, when $\alpha = 2$, it becomes the well-known Lane-Emden system. (Received September 19, 2010)

1067-35-1169 **Suncica Canic*** (canic@math.uh.edu), 4800 Calhoun Rd, Department of Mathematics, University of Houston, Houston, TX 77204-3008. *A moving interface problem in blood flow.*

The study of fluid-structure interaction between blood flow and compliant arterial walls is important in understanding the physiology and the pathology of the human cardiovascular system. The benchmark problem consists of solving the Navier-Stokes equations for an incompressible viscous fluid modeling blood flow in medium-to-large arteries, coupled with the equations of linearly viscoelastic shell modeling the compliant behavior of arterial walls. Due to the particular nonlinearity of the coupling, this problem is difficult to study from both the numerical and analytical points of view. To understand the basic properties of solutions and to simplify the analysis, we derived a reduced, effective model using ideas from homogenization theory. The resulting Biot model is a nonlinear moving-boundary problem of mixed type with degenerate diffusion, defined on a cylindrical domain in 3D. In this talk an existence result will be presented for the reduced Biot model assuming viscoelasticity of arterial walls with the lowest possible smoothing. Experimental results showing excellent comparison between numerical simulation and measurements will be discussed. An application to a problem arising in cardiovascular treatment will be presented. Collaborators: T.B. Kim and A. Mikelic. (Received September 19, 2010)

1067-35-1188 **Aghalaya S Vatsala*** (Vatsala@Louisiana.edu), Department of Mathematics, Lafayette, LA 70504-1010. *Existence of Coupled Extremal Solutions for Nonlinear Caputo Fractional Reaction Diffusion Equations.* Preliminary report.

We develop iterative methods for nonlinear fractional reaction diffusion equations using coupled upper and lower solutions. This is achieved using a comparison results related to fractional reaction diffusion equations. The iterative scheme provides sequences which converge uniformly and monotonically to coupled minimal and maximal solution of the nonlinear reaction diffusion equation. (Received September 19, 2010)

1067-35-1224 **Ariel Elizabeth Barton*** (aebarton@math.purdue.edu), Department of Mathematics, 150 North University Street, West Lafayette, IN 47907-2067. *Elliptic PDE and Carleson-measure estimates.*

Let u solve an elliptic PDE in a Lipschitz domain in the plane. Suppose that ∇u satisfies a Carleson-measure condition. I will show that, if the coefficients of the elliptic PDE have small imaginary part and are independent of one of the coordinates, then the boundary values of u exist and lie in BMO. (Received September 20, 2010)

1067-35-1264 **Tor A. Kwembe** (tor.a.kwembe@jsums.edu), P.O. Box 17610, Department of Mathematics, Jackson State University, Jackson, MS 39217, and **Zhenbu Zhang*** (zhenbu.zhang@jsums.edu), P.O.Box 17610, Department of Mathematics, Jackson State University, Jackson, MS 39217. *Blow-up properties for a semilinear reaction-diffusion system.* Preliminary report.

In this paper we consider a weak coupled semilinear parabolic system with general Wentzell boundary condition. We prove the local well-posedness of the problem and derive the conditions for global existence and finite time blow-up. We will also derive some estimates for blow-up time. (Received September 20, 2010)

1067-35-1267 **Wenxian Shen*** (wenxish@auburn.edu), Department of Mathematics and Statistics, Auburn University, Auburn, AL 36849, and **Aijun Zhang** (zhangai@auburn.edu), Department of Mathematics and Statistics, Auburn University, Auburn, AL 36849. *Spatial Spreading Dynamics in Nonlocal Monostable Equations in Spatially Periodic Habitats.*

This talk is concerned with spatial spreading dynamics of monostable equations with nonlocal dispersal in spatially periodic habitats. It first shows that a spatially periodic nonlocal dispersal operator has a principal eigenvalue for following three cases: (i) the nonlocal dispersal is nearly local; (ii) the periodic habitat is nearly globally homogeneous or (iii) it is nearly homogeneous in a region where it is most conducive to population growth. It also provides an example which shows that in general, a spatially periodic nonlocal dispersal operator may not possess a principal eigenvalue, which reveals some essential difference between random dispersal and nonlocal dispersal. In terms of the principal eigenvalues of nonlocal dispersal operators for the above mentioned special but important cases, it then shows that there is a unique spatially periodic positive stationary solution to a general spatially periodic nonlocal monostable equation and that there exists a spreading speed of the equation in every direction, which shows that spatial spreading feature is a generic feature in monostable equations. (Received September 20, 2010)

1067-35-1317 **Keng Deng*** (deng@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504, and **Zhihua Dong** (zxd5200@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504. *Blow-up for A Parabolic System with Nonlinear Memory.*

We consider nonnegative solutions of a parabolic system with nonlinear memory. We establish global existence and global nonexistence results. We also localize the blow-up points. (Received September 20, 2010)

1067-35-1355 **Xiang Xu*** (xu_x@math.psu.edu), 1400 Martin Street, Apt 2052, State College, PA 16803, and **Hao Wu** and **Chun Liu**. *Global existence and long time behavior of the general Ericksen-Leslie system.*

The Ericksen-Leslie system modeling the flow of nematic liquid crystals is a coupled system consisting of Navier-Stokes equations and kinematic transport equations for molecular orientation. First, through different energetic variational approaches, we get a physical derivation of the system, and distinguish conservative and dissipative parts of the induced stress terms. Then the existence of global classical solutions is proved, under the assumption of one large viscosity coefficient. Furthermore, by a suitable type Lojaciewicz-Simon inequality, we find the convergence of the classical solutions to steady states as time tends to infinity and get the estimate on the convergence rate. Finally, we study the well-posedness of the system when the initial data is near a functional minimizer, and reveal the relation between Parodi's condition and stability property of the liquid crystal system. (Received September 20, 2010)

1067-35-1362 **Jean-Paul Zolesio*** (Jean-Paul.Zolesio@inria.fr), INLN, 1361 routes des Lucioles, Sophia Antipolis, F-06560 Valbonne, France. *Variational Solution to Incompressible Euler Equation.*

Following previous work we adopt the tube variational principle. The set of admissible tubes is not a convex one, but using the transverse vector field technique we are able to built admissible perturbation of any optimal tube. The associated necessary condition leads to the usual Euler equation for incompressible fluids. We generalize this variational formulation for various constraints and discuss stability of solutions. (Received September 20, 2010)

1067-35-1377 **Qian Xu**, School of Mathematics, Capital Normal University, Beijing, Peoples Rep of China, **Xuefeng Wang*** (xdw@math.tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118, and **Yaping Wu**, School of Mathematics, Capital Normal University, Beijing, Peoples Rep of China. *Spiky steady states of chemotaxis systems via global bifurcation and Helly's compactness theorem.* Preliminary report.

The most important phenomenon about chemotaxis is the aggregation of "cells", for which we use spiky steady states to model. We carry out global bifurcation analysis on several variants of the Keller-Segel model, showing that positive steady states exist if the chemotaxis coefficient is large enough; then we use Helly's compactness theorem to obtain the asymptotics of these steady states as the chemotaxis coefficient tends to infinity, showing that they are spiky.

Compared to other methods, this one is much softer and simpler; however at this moment, the method works only in the case of 1D spatial domains. (Received September 20, 2010)

1067-35-1393 **Jacob Philip Bedrossian*** (jacob.bedrossian@math.ucla.edu), 3670 Glendon Ave, #229, Los Angeles, CA 90034. *Global existence for aggregation equations and Patlak-Keller-Segel models with degenerate diffusion.*

There is a wide interest in aggregation phenomenon modeling the competition between dispersal and nonlocal self-attraction. Well-studied examples are the parabolic-elliptic Patlak-Keller-Segel models (PKS) for chemotaxis. Similar models with less singular nonlocal interaction are studied as models for group formation in ecological systems, where degenerate diffusion is often used to account for over-crowding effects. Traditionally, PKS is studied with linear diffusion, however recently there has been increased interest in models with degenerate diffusion. In the recent work undertaken by my collaborators and I, we unify and extend the local and global wellposedness theory of these two kinds of models by studying general nonlocal aggregation equations with degenerate diffusion. Among other things, we generalize the traditional notion of criticality and the critical mass is estimated for a number of models. In particular, we show that the global existence is only governed by the asymptotic singularity of the interaction kernel at the origin and the growth of the diffusion at high concentrations. In my talk, I will discuss the global existence theory, and if time permits, the uniqueness of weak solutions and more recent developments. (Received September 20, 2010)

1067-35-1416 **M Affouf*** (maffouf@kean.edu), 1000 Morris Ave, Union, NJ 07083. *A numerical and analytical study of a variable-type equation.*

In this paper, we consider a fourth-order nonlinear partial differential equation modeling complex flows and transitions in material applications. The viscosity coefficient is a non convex function depending on gradient. The changing sign of viscosity leads to an alternating equation type. We derive a priori estimates for the solution of boundary-value problems. The structure and dynamics of interfaces and travelling wave solutions are numerically explored. (Received September 20, 2010)

1067-35-1417 **Netra Prakash Khanal*** (nkhanal@ut.edu), 401 W. Kennedy Blvd., Box 3F, Tampa, FL 33606. *Blow up Solution for Complex-valued Burgers Equation.*

Spatially periodic complex-valued solutions of the Burgers equation will be discussed. It is shown that for any sufficiently large time T, there exists an explicit initial datum such that its corresponding solution of the Burgers equation blows up at T. (Received September 20, 2010)

1067-35-1458 **Faranak Pahlevani*** (fxp10@psu.edu), 1600 Woodland Rd, Abington, PA 19001. *A Sensitivity Analysis for Partial Differential Equations with Applications.*

A technique for parameter sensitivity analysis of systems governed by partial differential equations is introduced. The presentation is focused on the use of sensitivity analysis for a fluid model (known as Eddy Viscosity Model) with respect to the variation of the filter length scale. The application of the sensitivity computations in improving flow functionals and identifying the reliable values of the parameter of interest is illustrated by two experiments: flow around a cylinder and the driven cavity problem. The finite element method is used in analysis and simulation of the flow solution as well as the flow sensitivity. (Received September 21, 2010)

1067-35-1511 **Catherine G Lebiedzik*** (ar6554@wayne.edu), Department of Mathematics, 1150 Faculty/Administration Bldg., 656 W Kirby, Detroit, MI 48202. *The Optimal Interior Regularity for the Critical Case of a Clamped Thermoelastic System with Point Control.*

In the case of clamped thermoelastic systems with interior point control defined on a bounded domain Ω, the critical case is $n = \dim \Omega = 2$. Indeed, an optimal interior regularity theory was obtained by R. Triggiani for $n = 1$ and $n = 3$. However, in this reference, an 'ϵ-loss' of interior regularity has occurred due to a peculiar pathology: the incompatibility of the boundary conditions of the spaces $H_0^{\frac{3}{2}}(\Omega)$ and $H_{00}^{\frac{3}{2}}(\Omega)$. This problem for $n = 2$ was rectified in a follow-up paper which establishes the sought-after interior regularity of the thermoelastic problem through a technical analysis based on sharp *boundary* (trace) regularity theory of Kirchhoff and wave equations. As an additional bonus, a sharp boundary regularity of the elastic displacement is also obtained. In the present paper, we revisit that problem using a technique developed in the context of structural acoustic systems to circumvent the pathology of the incompatable boundary conditions. This yields a more direct proof of the optimal interior regularity (but not of the boundary regularity). (Received September 21, 2010)

1067-35-1543 **Björn Bennewitz**, , Iceland, **John L Lewis**, Lexington, KY, **Kaj Nyström**, Umea, Sweden, and **Andrew L Vogel*** (alvogel@syr.edu), Syracuse, NY. *Estimates for the dimension of p-harmonic measure in $\mathbb{R}^n$.* Preliminary report.

For a positive solution u to the p-Laplace equation in a domain $\Omega \subset \mathbb{R}^n$ and vanishing on the boundary of Ω we associate a measure μ. For $p \geq n \geq 3$ and Ω a δ-Reifenberg flat domain for $\delta(p, n)$ small enough, the measure μ is concentrated on a set of σ-finite Hausdorff $n - 1$ measure. For $1 < p < n$ the situation is more interesting as some examples involving Wolff snowflakes demonstrate. The results here are similar to those obtained in $\mathbb{R}^2$ by Lewis, Nyström, Poggi-Corradini for Jordan domains bounded by quasicircles and simply connected domains. (Received September 21, 2010)

1067-35-1560 **Marian Bocea*** (marian.bocea@ndsu.edu), North Dakota State University, Dept. of Mathematics, NDSU Dept. # 2750, P.O. Box 6050, Fargo, ND 58108-6050. *Models for growth of heterogeneous sandpiles via Mosco convergence.*

The asymptotic behavior of certain power-law functionals involving variable exponents is studied in the framework of Mosco convergence. The convergence results are applied to model the growth of sandpiles in which the allowed slope of the sand depends explicitly on the position in the sample. Joint work with M. Mihailescu, M. Perez-Llanos, and J.D. Rossi. (Received September 21, 2010)

1067-35-1590 **Jan Sokolowski*** (Jan.Sokolowski@iecn.u-nancy.fr), Institut Elie Cartan, UMR 7502, Nancy-Universite-CNRS-INRIA, Universite Henri Poincare Nancy 1 BP 239, 54506 Vandoeuvre-Les-Nancy, France, and **P.I. Plotnikov**. *Nonhomogeneius boundary value problems for non-stationary compressible Navier-Stokes equations and work minimization.*

In the paper [1] we prove the new result on the existence of weak renormalized solution to in/out flow problem for nonstationary compressible Navier-Stokes equations posed in a bounded domain with an obstacle inside. The result of [1] is employed to obtain the existence of an optimal shape of the obstacle which minimizes the work for a given flight scenario. [1] P.I. Plotnikov, J. Sokolowski,INHOMOGENEIUS BOUNDARY VALUE PROBLEM FOR NONSTATIONARY COMPRESSIBLE NAVIER-STOKES EQUATIONS, Journal of Mathematical Sciences, Vol. 170, No. 1, 2010, Springer Verlag,pp 34-130. (Received September 21, 2010)

1067-35-1607 **Justin L Taylor*** (jtaylor2@ms.uky.edu), 906 Patterson Office Tower, University of Kentucky, Lexington, KY 40506-0027. *Convergence of Eigenvalues for Elliptic Systems on Perturbed Domains with Low Regularity.*

We consider the eigenvalues of an elliptic operator

$$(Lu)^\beta = -\frac{\partial}{\partial x_j}\left(a_{ij}^{\alpha\beta}\frac{\partial u^\alpha}{\partial x_i}\right) \qquad \beta = 1, ..., m$$

where $u = (u^1, ..., u^m)^t$ is a vector valued function and $a^{\alpha\beta}(x)$ are $(n \times n)$ matrices whose elements $a_{ij}^{\alpha\beta}(x)$ are uniformly bounded measurable real-valued functions such that

$$a_{ij}^{\alpha\beta}(x) = a_{ji}^{\beta\alpha}(x)$$

for any combination of α, β, i, and j. We considertwo non-empty, open, disjoint, and bounded sets, Ω and $\widetilde{\Omega}$ in $\mathbb{R}^n$ with low regularity, and add a set T_ε of small measure to form the domain Ω_ε. Then we show that as $\varepsilon \to 0^+$, the Dirichlet eigenvalues corresponding to the family of domains $\{\Omega_\varepsilon\}_{\varepsilon>0}$ converge to the Dirichlet eigenvalues corresponding to $\Omega_0 = \Omega \cup \widetilde{\Omega}$. (Received September 21, 2010)

1067-35-1609 **Timur Milgrom*** (tm454@drexel.edu), Drexel University, Department of Mathematics, Korman Center 209, 3141 Chestnut St., Philadelphia, PA 19104, and **David M. Ambrose**, Drexel University, Department of Mathematics, Korman Center 275, 3141 Chestnut St., Philadelphia, PA 19104. *An existence and uniqueness theorem for periodic solutions to Boussinesq equations.* Preliminary report.

We consider a quasilinear partial differential equation where the nonlinearities satisfy a Lipschitz property. The boundary value problem is studied using Dirichlet, Neumann and mixed boundary conditions. A fixed point argument is used to show existence and uniqueness of a periodic solution. Finally, as an example we show existence and uniqueness of a periodic solution to certain Boussinesq equations. (Received September 21, 2010)

1067-35-1627 **Jann-Long Chern**, National Central University, Taiwan, **Chang-Shou Lin**, Taiwan University, Taiwan, **Junping Shi*** (shij@math.wm.edu), College of William and Mary, Williamsburg, VA 23187, and **Yong-Li Tang**, National Central University, Taiwan. *Uniqueness of positive solution to semilinear elliptic systems.*

The steady state solutions of a reaction-diffusion system usually satisfy a system of semilinear elliptic equations. While the existence of positive solutions can be shown with various ways, the uniqueness or exact multiplicity of positive solutions is difficult to obtain. We review some known results and recent work for sublinear systems and also radially symmetric solutions. (Received September 21, 2010)

1067-35-1679 **Thomas J. Bieske*** (tbieske@math.usf.edu), 4202 E. Fowler Ave., PHY 114, Tampa, FL 33620, and **John Ryan**, 301 SCEN, University of Arkansas, Fayetteville, AR 72701. *The Infinite Dirac Operator.*

We define the infinite Dirac operator and explore some key properties, particularly its conformal invariance. We also introduce the infinite Dirac operator on the sphere S^n and establish the relationship between the two infinite Dirac operators via the Cayley transformation. (Received September 21, 2010)

1067-35-1703 **Diane Denny*** (diane.denny@tamucc.edu), Department of Mathematics and Statistics, Texas A&M University-Corpus Christi, 6300 Ocean Drive, Corpus Christi, TX 78412. *Existence of a unique solution to a quasilinear elliptic equation with data at an interior point of the domain.* Preliminary report.

We prove the existence of a unique classical solution $u(\mathbf{x})$ to the quasilinear elliptic equation $-\nabla \cdot (a(u)\nabla u) + \mathbf{v} \cdot \nabla u = f$, where $u(\mathbf{x}_0) = u_0$ at a point $\mathbf{x}_0 \in \Omega$ and where $\mathbf{n} \cdot \nabla u = g$ on the boundary of the domain Ω. Applications include stationary heat/diffusion problems with convection and with a source/sink where the value

of the solution is known at a spatial location $\mathbf{x}_0 \in \Omega$ and where $\mathbf{n} \cdot \nabla u$ is known on the boundary. (Received September 21, 2010)

1067-35-1726 **Guillaume Bal*** (gb2030@columbia.edu), 500 W. 120th St, New York, NY 10027.
Quantitative photoacoustics and other hybrid inverse problems.

Hybrid medical imaging techniques aim to combine the good contrast properties of one modality with the good resolution properties of another one. Mathematically, several of these imaging techniques concern the reconstructions of constitutive parameters in partial differential equations from availability of values of functionals of the PDE solution inside the domain of interest (even though physical measurement are performed at the domain's boundary as a non-invasive technique). This talk will review several models, and in particular photo-acoustics and acousto-optics, and what can be said about them from the mathematical viewpoint. (Received September 21, 2010)

1067-35-1729 **Mihalis Mourgoglou*** (mmbqb@mail.missouri.edu), Mathematics Department, 21 Math Sciences Bldg, University of Missouri, Columbia, MO 65211. *C^α and BMO solvability of Dirichlet problem for divergence form elliptic equations with complex L^∞ coefficients.*

We consider divergence form elliptic equations $Lu := \nabla \cdot (A\nabla u) = 0$ in the half space $\mathbb{R}^{n+1}_+ := \{(x,t) \in \mathbb{R}^n \times (0,\infty)\}$, whose coefficient matrix A is complex elliptic, bounded and measurable. In addition, we suppose that A satisfies some additional regularity in the direction transverse to the boundary, namely that the discrepancy $A(x,t) - A(x,0)$ satisfies a Carleson measure condition of Fefferman-Kenig-Pipher type, with small Carleson norm. Under these conditions, we obtain solvability of the Dirichlet problem for L, with data in either BMO or in the space of Hölder continuous functions C^α with α small enough, assuming that we have the same solvability result for the t-independent operator $L_0 := \nabla \cdot (A(\cdot,0)\nabla)$. (Received September 21, 2010)

1067-35-1778 **Alex A. Himonas*** (himonas.1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *On the well-posedness of Camassa-Holm type equations.*

We shall discuss the well-posedness in Sobolev spaces for a class of weakly dispersive nonlinear evolution equations including the Camassa-Holm and the Degasperis Procesi equations. This talk is based on work in collaboration with Carlos Kenig, Gerard Misiolek, and Curtis Holliman. (Received September 21, 2010)

1067-35-1783 **Robin Ming Chen*** (chenm@math.umn.edu), 206 Church St. SE, School of Mathematics, Minneapolis, MN 55455. *Wave-breaking for a generalized two-component Camassa-Holm system.*

We study a generalized two-component Camassa-Holm system which can be derived from the theory of shallow water waves moving over a linear shear flow. This new system also generalizes a class of dispersive waves in cylindrical compressible hyperelastic rods. We show that this new system can still exhibit the wave-breaking phenomenon. Also a sufficient condition for global solutions is established. This is a joint work with Yue Liu. (Received September 21, 2010)

1067-35-1793 **Zhongyi Nie** and **Russell M. Brown***, Department of Mathematics, University of Kentucky, Lexington, KY 40503. *Estimates for a family of multi-linear forms.*

We consider a family of n-linear forms and establish uniform estimates as n increases. We apply these estimates to study a scattering map that arises in several contexts including the inverse conductivity problem and the solution of one of the Davey-Stewartson equations by the method of inverse scattering. (Received September 21, 2010)

1067-35-1840 **Dhanapati Adhikari*** (dadhika@math.okstate.edu), 401 Mathematical Sciences, Stillwater, OK 74078, and **Chongsheng Cao** and **Jiahong Wu**. *Global regularity results for the 2D Boussinesq equations with vertical dissipation.* Preliminary report.

This paper furthers the study of Adhikari, Cao and Wu [Journal of Differential Equations **249** (2010) No. 5 1078-1088] on the global regularity issue concerning the 2D Boussinesq equations with vertical dissipation and vertical thermal diffusion. The norm of the vertical velocity v in the Lebesgue space L^q with $2 \le q < \infty$ is shown to be bounded by $C_1\, q$ for C_1 independent of q. This bound significantly improves the previous exponential bound in q. In addition, we prove that, if v satisfies $\int_0^T \sup_{q\ge 2} \frac{\|v(\cdot,t)\|^2_{L^q}}{q}\, dt < \infty$, then the associated solution of the 2D Boussinesq equations preserve its smoothness on $[0,T]$. In particular, $\|v\|_{L^q} \le C_2\sqrt{q}$ implies global regularity. (Received September 22, 2010)

1067-35-1924 **Peter R Wolenski*** (wolenski@math.lsu.edu), Dept. of Math, Louisiana State University, Baton Rouge, LA 70803. *New regularity conditions for the minimal time function.* Preliminary report.

We consider the minimal time problem associated with a closed target set and with dynamics given in the form of a differential inclusion. We shall provide new conditions that ensure the minimal time function has the property of being semiconcave. (Received September 22, 2010)

1067-35-1931 **U Pablo Suarez*** (psuarez@desu.edu), Department of Mathematical Sciences, Delaware State University, 1200 N. DuPont Highway, Dover, DE 19901. *Galerkin boundary integral analysis of the Grad-Shafranov equation.*

The Magneto Hydrodynamic equilibrium in an axisymmetric plasma is described in terms of the magnetic flux by the Grad-Shafranov Equation. This equation is commonly solved via domain-based discretization approaches such as finite difference and finite element methods. However for plasma equilibrium analysis on actual fusion devices (e.g., Tokamaks) a boundary-only discretization techniques can be very attractive. In a boundary integral equation framework, only the surface of the plasma is discretized and geometric modifications and updates of the plasma surface are inexpensive.

In what follows we solve the Grad-Shafranov Equation using the Galerkin Boundary Element Method. We solve this non-linear partial differential equation combining the Dual Reciprocity Method with an iterative scheme. An expansion of the nonlinearity is given in terms of particular solutions of the Grad-Shafranov equation. Then an iteration procedure is applied to solve the PDE with the source expanded in terms of particular solutions. We can simplify the PDE to a homogenous one. When we apply the iteration procedure we update the boundary conditions only. In this fashion the problem is solved by using Galerkin boundary integral analysis. (Received September 22, 2010)

1067-35-1948 **Zhigang Zhang*** (zgzhang@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77004. *Positioning the Z-ring near the mid-cell via the spatio-temporal oscillation of the Min system.*

The division of many bacterial cells like E. coli cells involves the assembly and eventual contraction of a ring structure at the middle of the cell, which is mostly composed of FtsZ proteins. The positioning of the Z-ring is crucial, and is regulated partially by the Min-protein system. The spatio-temporal oscillation produced by the Min proteins results in a low average of MinD protein concentration near the cell center. On the membrane, FtsZ proteins near the poles, where the MinD concentration is high, are more likely to reenter the cytoplasm, while they congregate at the center and form a Z-ring. Lateral association between FtsZ filaments is also important for the establishment of the Z-ring and other superstructures, while MinD proteins promote the dissociation of lateral associations between FtsZ filaments. We built a one dimensional diffusion-advection-reaction model for the Min-proteins and FtsZ filaments. A convolution is used to estimate the movement of FtsZ molecules caused by the alignment of the FtsZ filament. Simulation results are consistent with experiments. (Received September 22, 2010)

1067-35-1962 **Ronald Mickens*** (rohrs@math.gatech.edu), Clark Atlanta University, Physics Department, Atlanta, GA 30314. *An Exactly Solveable SIR Model Having Population Dynamics.*

We construct a SIR epidemiological model where the various population transition terms have fractional powers. The model also contains logistic-like population dynamics and thus corresponds to disease spread where the disease time scale is comparable to the average lifespan of the general population. An important feature of this model is that for given relevant initial conditions the exact solution can be calculated. An examination of the S-I phase-space allows the determination of all the critical parameters for this model of the spread of disease. A discussion of the methodology for SIR model construction will be presented as well as how the current work can be generalized. (Received September 22, 2010)

1067-35-1983 **Yi Li*** (yi-li@uiowa.edu), Iowa City, IA 52242, and **Shuangjie Peng** (sjpeng@mail.ccnu.edu.cn), Wuhan, Hubei , Peoples Rep of China. *Multi-peak Solutions to Two Types of Free Boundary Problems.*

We consider the existence of multi-peak solutions to free boundary problems arising in confined plasma and steady vortex pair under conditions on the nonlinearity we believe to be almost optimal. Our results show that the core of the solution has multiple connected components, whose boundary called free boundary of the problems consists approximately of spheres which shrink to distinct single points as the parameter tends to zero. (Received September 22, 2010)

1067-35-1989 **Yuliya Gorb*** (gorb@math.uh.edu), University of Houston, Department of Mathematics, PGH 636, Houston, TX 77204. *L-infinity estimates for gradients of solutions to some nonlinear problems.* Preliminary report.

In this talk a general framework allowing for L-infinity estimates for gradients of solutions to a class of nonlinear PDE problems will be described. The presentation of main results is given on a prototypical example based on the p-Laplacian and describing a composite material consisting of a matrix of finite conductivity with two injected perfectly conducting particles close to touching. The small distance between particles and high contrast in mechanical properties of composite constituents lead to localization of so-called high concentration zones where the gradient of the solution exhibits singular behavior. The main goal of the developed approach is to capture and characterize the blow up of the solution gradient which describes electric field of the two-phase composite. (Received September 22, 2010)

1067-35-2009 **Michael T. Heitzman*** (heitzmanmt@gmail.com), 16 E. Stewart Rd. Apt. 7, Columbia, MO 65203, and **Carmen Chicone** (chiconec@missouri.edu), Mathematics Department, 202 Mathematical Sciences Bldg, University of Missouri, Columbia, MO 65211. *A nonlinear free boundary problem in gas dynamics.*

Motivated by the two-body problem in the classical field theories of electrodynamics and gravitation, we have developed a free boundary problem in gas dynamics to explore the motion of sources in a medium whose dynamics are governed by hyperbolic PDEs arising from physical conservation laws. In our model, the medium is a gas confined to a tube, and the sources are pistons which form a free boundary at each end. The pistons are attached to springs, and behave as damped harmonic oscillators driven by fluctuations in the gas pressure and density fields. The fields are governed by the nonlinear PDEs of gas dynamics, with the motion of the pistons included as boundary conditions. The coupled system is a nonlinear PDE/ODE hybrid with free boundary. In the linearized acoustic model, the fields are eliminated by the method of characteristics, yielding functional differential equations for the motion of the sources. These are approximated by reduction to a finite dimensional manifold. We also treat the full nonlinear free boundary problem and show that unique classical solutions exist locally in time, for initial fields close enough to their constant steady state. This is done by transforming to Lagrangian coordinates to fix the boundary, and applying the contraction mapping principle. (Received September 22, 2010)

1067-35-2010 **Tomoyuki Kakehi*** (kakehi@math.tsukuba.ac.jp), Department of Mathematics, Okayama University, Tsushima Naka 3-1-1, Okayama city, Okayama 700-8530, Japan. *L^2-wellposedness for Schrödinger type equations on $\mathbf{S}^n$.* Preliminary report.

In our talk, we deal with Schrödinger type equations of the form $i\partial_t u = \Delta_{\mathbf{S}^n} u + Bu + c(x)u + f(t,x)$. Here B is a complex valued vector field on $\mathbf{S}^n$ and $c(x)$ is a smooth function. Under some assumption on ReB, we will give a necessary and sufficient condition for the L^2-wellposedness of the above equation, using the geodesic Radon transform of a certain one form on $\mathbf{S}^n$ associated with ReB. (Received September 22, 2010)

1067-35-2048 **Vincent J van Joolen*** (vanjoole@usna.edu), 219 Holland Rd, Severna Park, MD 21146. *A Round Peg in a Square Hole? Application of Non-uniform Rectangular Grid Schemes to Circular Domains.*

One might deem the use of rectangular finite difference schemes on circular domains as an oxymoron, or quite literally, "forcing a round peg into a square hole". However, recently developed equations for non-uniform rectangular grids can be effectively applied to a variety of non-rectangular domains. This paper presents the development of these equations and numerically demonstrates their use to approximate the behavior of a classical wave equation on a circle with Dirichlet boundary conditions. Numerical solutions are compared to analytic Bessel series solutions. Improvements to numerical solutions are explored by modifying grid-schemes. (Received September 22, 2010)

1067-35-2096 **Aubrey Rex Rhoden*** (aubrey.rhoden@mavs.uta.edu), 408 E. Second St., arlington, TX 76010, and **Natee Pantong**. *A Globally Convergent Numerical Method for Coefficient Inverse Problems with Applications in Thermal Tomography.*

In our terminology "globally convergent numerical method" means a numerical method, whose convergence to a good approximation for the correct solution is independent of the initial approximation. A new numerical imaging algorithm has been proposed to solve a coefficient inverse problem for an elliptic equation with the data generated by computer simulation. A rigorous convergence analysis shows that this method converges globally. A heuristic approach for approximating the "new tail-function" which is a crucial part (assuming the smallness of the tail-function) of our problem has been utilized and verified in numerical experiments, so as the global convergence. Applications to both optical and thermal tomography are discussed. Numerical experiments in the 2D thermal property reconstruction are presented. (Received September 22, 2010)

1067-35-2106 **Milton C Lopes Filho** (mlopes@ime.unicamp.br), **Dongjuan Niu** (niuniudj@gmail.com), **Edriss S Titi** (etiti@math.uci.edu) and **Helena J Nussenzveig Lopes*** (hlopes@ime.unicamp.br), Department of Mathematics, IMECC, Rua Sergio Buarque de Holanda, 651, University of Campinas - UNICAMP, Campinas, SP 13083-859, Brazil. *Two-dimensional incompressible flows as limits of 3D helical flows.* Preliminary report.

It is known that the three-dimensional Navier-Stokes equations are invariant under helical symmetry and well-posed, globally in time. In this talk we investigate the limit behavior of a family of helical, viscous flows to their corresponding two-dimensional limits, in two different situations. First, we consider the limit as the helices become straight lines. Next we consider the limit as the helices oscillate strongly and flatten out. In the latter scenario there is an intimate relation between this limit behavior and the limit behavior of the Navier-Stokes equations in a thin domain with vanishing thickness. (Received September 22, 2010)

1067-35-2125 **Ellen Shiting Bao*** (shbao@math.umn.edu), 206 Church St SE, Minneapolis, MN 55455, and **Haigang Li**, **Yanyan Li** and **Biao Yin**. *Gradient estimates for elliptic equation and system from composite media.*

We establish both upper and lower bounds of the gradient estimates for solutions to the perfect conductivity problem in the case where perfect (stiff) conductors are closely spaced inside an open bounded domain. These results give the optimal blow-up rates of the stress for conductors with arbitrary shape and in all dimensions. We also obtain an upper bound of the gradient estimates to the insulated case. As for system we recently derive local gradient estimates when the solution takes constant values on the inclusions. (Received September 22, 2010)

1067-35-2159 **Michael Hintermueller*** (michael.hintermueller@uni-graz.at), University of Graz, Mathematics and Scientific Computing, Heinrichstrasse 36, A-8010, Graz, Austria. *Electrical impedance tomography: from topology to shape.*

Electrical impedance tomography is an imaging modality which aims at detecting hidden inclusions from electrical measurements by exploiting conductivity or permittivity properties of the hidden objects. In this talk, extended topological expansions of the solution of the underlying partial differential equation system are presented. These expansions provide information on the distribution (topology) of the objects within a surrounding medium. In a second step shape sensitivities are computed and both, topological derivatives and shape derivatives, are realized algorithmically. The talks ends by a report on numerical tests. (Received September 23, 2010)

1067-35-2182 **Anahit Galstyan*** (agalstyan@utpa.edu), Department of Mathematics, University of Texas-Pan American, 1201 West University Drive, Edinburg, TX 78539. *Some hyperbolic equations arising in mathematical cosmology.*

In 1917, shortly after development of General Theory of Relativity, Einstein and then de Sitter proposed model of universe based on Einstein's gravitational theory. Since that time the wave equations arising in the de Sitter model of universe are subject of the research of huge number of physicists and mathematicians. But very important problems of the finding of the fundamental solutions and the representation formulas for the solutions of the Cauchy problem for these partial differential equations are not solved. We will present representation formulas for the solutions of the Cauchy problem for the wave and Klein-Gordon equations in the de Sitter and Einstein&de Sitter metric. We believe that the explicit representation formulas introduced in this talk fill the gap in the existing literature on the initial value problems for the above mentioned equations. (Received September 22, 2010)

1067-35-2191 **Danny Arrigo*** (darrigo@uca.edu), Department of Mathematics, 201 Donaghey Ave., Conway, AR 72035, and **David Ekrut**, **Long Le** and **Sang Lee**. *Nonclassical symmetries of a reaction-diffusion equation with a quadratic nonlinearity.*

Recently it has been shown that compatibility between a given PDE and a general first order quasilinear PDE gives rise to its nonclassical symmetries. Here we consider the compatibility between both a first and second order equation and a (2+1) dimensional reaction-diffusion equation with a quadratic nonlinearity. We discuss both the similarities and differences when going from first order compatibility to second order compatibility. (Received September 22, 2010)

1067-35-2204 **James Francis Hickman*** (jh1659@ship.edu), 20 Carla Drive, Shippensburg, PA 17257.
Finite Difference Methods for Solving the Coupled Non-Linear Euler-Bernoulli Beam Equations, with applications to modeling the wing of a Micro Air Vehicle.

Over the past decade the development of Micro-Air-Vehicles (MAV's) has been of interest to several groups. In particular the military envisions it as a potentially vital aspect of their intelligence division. This is certainly not the only function for this emerging technology, private companies also envision applying it to a variety of applications as well. This paper will focus on using a non-linear form of the Euler-Bernoulli beam equation in an attempt to model the batons of a flexible winged MAV. First the equations which constitute the core of this research will be derived using the principles of Hamiltonian Mechanics combined with ideas from Continuum mechanics. After the derivation is completed a numerical algorithm will be discussed which consists primarily of finite difference approximations which use iterative methods to solve this coupled system. Further advances in this area of study could incorporate a model which encompassed the entire wing, simulations based on material constraints, and finally integration of the principles of fluid mechanics into the problem to make it more relevant and applicable. This work has been completed as a part of the 2010 REU Program at George Mason University funded by the NSF-REU and DOD-ASSURE Programs. (Received September 22, 2010)

1067-35-2242 **Sharad D Silwal*** (sharad@math.ksu.edu), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506, **Sapto Indratno** (sapto@math.ksu.edu), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506, and **Diego Maldonado** (dmaldona@math.ksu.edu), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506. *The axiomatic approach to Harnack's inequality in doubling quasi-metric spaces.* Preliminary report.

We present an alternative approach to the abstract proof of Harnack's inequality in the setting of doubling quasi-metric spaces. This approach, mostly based on the theory of weights, sheds some new light onto the role of the so-called critical density property. This is joint work with Sapto Indratno and Diego Maldonado from KSU. (Received September 22, 2010)

1067-35-2360 **Gurgen Hayrapetyan*** (hayrapet@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824, and **Keith Promislow**, Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Spectrum of Constrained Gradient Flows of Functionalized Energies.* Preliminary report.

A fourth order partial differential operator with a small parameter and a nonlocal constraint is considered. The impact of the spectrum of the one dimensional leading part of the operator on the spectrum of the full operator in $\mathbb{R}^n$ is analyzed. It is shown that the eigenfunctions corresponding to asymptotically small eigenvalues have a separated variables form in terms of eigenfunctions of a Sturm-Liouville operator and eigenfunctions of a constrained Laplace-Beltrami operator. Several results on the effect of small perturbations on the spectral structure of certain self-adjoint linear operators are established. These results are applicable to analysis of stability of higher-order curvature driven flows that arise in modeling of solvated functionalized polymers. (Received September 22, 2010)

1067-35-2384 **Haiyan Tian*** (haiyan.tian@usm.edu), 118 College Dr. #5045, Hattiesburg, MS 39406, and **Andreas Grunewald**, 53113 Bonn, Germany. *A direct method for solving an ill-posed inhomogeneous elliptic problem.*

A delta-shaped basis method is used for reducing an inhomogeneous elliptic problem to a homogeneous one. The method of fundamental solutions combined with proper regularization technique is then used for the resulting homogeneous problem to obtain a stable solution. (Received September 23, 2010)

1067-35-2405 **Ian Johnson*** (ijohnso1@gmu.edu), 7570 Remington Road, Manassas, VA 20109.
Bifurcation and Continuation Analysis of Equilibria of the Diblock Copolymer Equation in One Dimension. Preliminary report.

Diblock copolymers are a class of materials formed by the reaction of two linear polymers. The different structures taken on by these polymers grant them special properties, which can prove useful in applications such as development of new adhesives and asphalt additives. The diblock copolymer equation governs the formation of these polymers. Using the software package AUTO, continuation analysis of the equilibria of the diblock copolymer equation in one dimension was performed. In addition, consideration of the energy associated with the system was performed, which enables a limited analysis of the relationships between the equilibria in the time-varying model. (Received September 23, 2010)

37 ► Dynamical systems and ergodic theory

1067-37-31 **Gregory A Kelsey*** (gkelsey2@illinois.edu), 300 S. Goodwin Ave., Apt. 609, Urbana, IL 61801. *Mapping Schemes Realizable by Obstructed Topological Polynomials.*

In 1985, Levy used a theorem of Berstein to prove that all hyperbolic topological polynomials are equivalent to complex polynomials. We prove a partial converse to the Berstein-Levy Theorem: given post-critical dynamics that are, in a sense, strongly non-hyperbolic, we prove the existence of topological polynomials realizing these post-critical dynamics which are not equivalent to any complex polynomial. This proof employs the theory of self-similar groups to demonstrate that a topological polynomial admits an obstruction, and produces a wealth of examples of obstructed topological polynomials. (Received June 06, 2010)

1067-37-164 **Joshua J Clemons*** (jclemons@vt.edu), Joshua Clemons, Dept. of Mathematics, 460 McBryde, Virginia Tech, Blacksburg, NC 24061-0123. *Quadratic-like mappings and iterated Weierstrass elliptic functions.*

Using the pioneering work of Douady and Hubbard on so called polynomial-like mappings, we show that the parameter space (properly defined) of Weierstrass elliptic functions on square lattices contains infinitely many dynamically distinct Mandelbrot sets. We make use of a square "checkered" tiling of the plane to describe the locations of these Mandelbrot sets. This is completed PhD work under the supervision of Jane M. Hawkins. (Received July 28, 2010)

1067-37-198 **Hanfeng Li*** (hfli@math.buffalo.edu), Department of Mathematics, SUNY at Buffalo, Buffalo, NY 14260-2900. *Entropy and Fuglede-Kadison determinant.*

For any discrete group G and any element f in the integral group ring ZG of G, one may consider the algebraic action of G associated to f, i.e., the shift action of G on the Pontryagin dual of ZG/ZGf. I will discuss the relation between the entropy of this algebraic action and the Fugelde-Kadison determinant of f in the group von Neumann algebra of G. (Received August 01, 2010)

1067-37-249 **Aslihan Demirkaya*** (ademirkaya@math.ku.edu), Lawrence, KS 66044. *Long Time Behavior of radially symmetric solutions of higher dimensional Kuramoto-Sivashinsky Equation.*

We consider the radially symmetric solutions of the Kuramoto Sivashinsky equation in a shell domain $r_0 \leq r \leq R_0$ in any dimension n. Using Lyapunov function approach, we study the long time behavior of the solutions and prove that there exists a time independent bound for the L^2 norm of the solution. First we prove the result for any n-dimensional shell domain which does not contain the origin. Then we include the origin and show the similar results for some special radially symmetric solutions. (Received August 12, 2010)

1067-37-304 **David Kerr*** (kerr@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368, and **Hanfeng Li** (hfli@math.buffalo.edu), Department of Mathematics, SUNY at Buffalo, Buffalo, NY 14260-2900. *Entropy and the variational principle for actions of sofic groups.*

Recently Lewis Bowen introduced a notion of entropy for measure-preserving actions of a countable sofic group on a standard probability space admitting a generating partition with finite entropy. Using an operator algebra perspective we develop a more general approach to sofic entropy which produces both measure and topological dynamical invariants, and we establish the variational principle in this context. (Received August 18, 2010)

1067-37-313 **Christina Battista***, School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester Institute of Technology, Rochester, NY 14623, and **Jeannette Benham**, Department of Mathematics, PO Box 5000, Bard College, Annandale-on-Hudson, NY 12504-5000. *Bifurcation structure of external cavity mode and compound laser mode solutions.*

External cavity semiconductor lasers are commonly used in various important fields such as optical fiber communications and data recording. The main model in the understanding of the dynamics of these lasers is the well-known Lang-Kobayashi equations, consisting of two delay differential equations for the complex electrical field E and the carrier number density N. The model contains five parameters and exhibits various bifurcations. In our research, we were interested in special solutions, called External Cavity Mode (ECM) solutions. These solutions appear through saddle-node bifurcations as the feedback parameter is changed, then lose stability through a Hopf bifurcation at higher feedback levels. We investigated the structure of these bifurcations on the feedback level-external cavity roundtrip time parameter space and established the possibility of the coexistence of stable ECM solutions. In the more difficult case of delay-coupled lasers, solutions of analogous form are called Compound Laser Mode (CLM) solutions. We also studied the stability of these solutions and the bifurcation possibilities as the detuning parameter changed. Our goal is to extend this analysis to describe the full bifurcation structure of CLM solutions. (Received August 19, 2010)

1067-37-1106 **Youssef Naim Raffoul*** (youssef.raffoul@notes.udayton.edu), Department of Mathematics, Dayton, 45469-2316, and **Murat Adivar** (murat.adivar@ieu.edu.tr), Izmir, Turkey. *Shift operators and stability in delayed dynamic equations.*

In this paper, we use what we call (Adivar-Raffoul) shift operator so that general delay dynamic equations of the form

$$x^{\Delta}(t) = a(t)x(t) + b(t)x(\delta_-(h,t))\delta_-^{\Delta}(h,t), \quad t \in [t_0, \infty)_{\mathbb{T}}$$

can be analyzed with respect to stability and existence of solutions. By means of the shift operators we define a general delay function opening an avenue for the construction of Lyapunov functional on time scales. Thus, we use Lyapunov's direct method to obtain inequalities that lead to stability and instability. Therefore, we extend and unify stability analysis of delay differential, delay difference, delay $h-$difference, and delay $q-$difference equations which are the most important particular cases of our delay dynamic equation.
(Received September 18, 2010)

1067-37-1121 **Elif Demirci*** (edemirci@science.ankara.edu.tr), Ankara University Faculty of Sciences, Department of Mathematics, Besevler, 06100 Ankara, Turkey, and **Nuri Ozalp** (nozalp@science.ankara.edu.tr). *On a Fractional Order Epidemic Model.*

Fractional order calculus is an old branch of thoeretical mathematics. Nevertheless, it has recently being used in describing real systems. We introduce an epidemic model of fractional order within a population that grows logistically. We give some stability results for the fixed points of the system. We also give a numerical example using a real data set for HBV and determine the order of the system for this data set. (Received September 19, 2010)

1067-37-1241 **Fathallah-Shaykh M Hassan*** (hfathall@uab.edu), FOT 1020, 1530 3RD Avenue South, Birmingham, AL 35294-3410. *High-Dimensional Counterexamples of the Kaplan-Yorke Conjecture: Fractal Dimension of the Drosophila Circadian Clock.*

Kaplan and Yorke conjectured that the dimension of a strange attractor can be approximated from the spectrum of its Lyapunov exponents. Clockwork Orange (CWO) is transcriptional repressor of direct target genes that appears to play a key role in controlling the dynamics of the Drosophila circadian clock. The box-counting and Kaplan-Yorke dimensions of models of the Drosophila circadian clock reveal that these strange attractors as counterexamples of the Kaplan-Yorke conjecture and highlight the complexity of the time-keeping actions of CWO in light-day cycles. (Received September 20, 2010)

1067-37-1533 **Jeremy Avigad*** (avigad@cmu.edu), Department of Philosophy, Baker Hall 135, Carnegie Mellon University, Pittsburgh, PA 15213. *Inverting the Furstenberg correspondence.*

Roughly speaking, the Furstenberg correspondence principle shows that given any sequence of sets $S_n \subset \{0,\dots,n-1\}$, there exists a subsequence and a measure μ on $2^{\mathbb{N}}$ which reflects the limits of the densities with which patterns occur in that subsequence. I will explain how this process can be inverted, so that any measure μ on $2^{\mathbb{N}}$ (not necessarily ergodic) can be represented by such a subsequence. Similarly, factors of μ can be represented as limits of appropriate "factors" of the elements of this subsequence. More generally, I will discuss some of the relationships between ergodic-theoretic and finite fourier-analytic methods in ergodic Ramsey theory that play a key role in work by Tao. (Received September 21, 2010)

1067-37-1576 **David S. Richeson*** (richesod@dickinson.edu), Department of Mathematics and Comp Sci, Dickinson College, Carlisle, PA 17013, and **Jim Wiseman** and **Fabio Drucker**. *Symbolic dynamics from partitions with overlapping elements.* Preliminary report.

Let X be a compact metric space, $f : X \to X$ be a continuous map, and $\{N_1,\dots,N_n\}$ be a collection of nonempty compact sets. We say that $(s_0, s_1, \dots)$ is an *itinerary* for a point x if $f^i(x) \in N_{s_i}$ for all i. In the classical case of a Markov partition, the sets N_i overlap only on their boundaries and map across each other nicely under f; in this case the itineraries give symbolic dynamics in the form of a subshift of finite type. In this work we study the case where the sets N_i can overlap nontrivially and can map across each other in more complicated ways. We discuss methods for extracting useful information about the dynamics of f (such as a nonzero lower bound for the topological entropy) from the itineraries. (Received September 21, 2010)

1067-37-1584 **R E Lampe*** (rlampe@copper.net), 6 Warrenton Circle, Richmond, VA 23229. *Orbit distributions in iterated function systems with finitely many forms.*

Let $\mathcal{F} = \{f_i\}_{i \in I}$ be a family of measure preserving self maps on a measure space $\{X, \Sigma, \mu\}$, indexed by a finite set I. For a sequence $\alpha = a_1, a_2, \ldots$ with $a_i \in I$, the n-fold composition with respect to α is $F^n_\alpha = f_{a_n} \circ F^{n-1}_\alpha$. When the n-fold compositions from the family $\mathcal{F}$ take finitely many forms, we show the discrete time distribution for the orbit of $F^k_\alpha(x_0)$ is a weighted average of the discrete time distributions of the orbits of the finite forms at the point x_0 for μ-almost all x_0 and for almost all α. This weighted average is arrived at by showing that an independence condition holds by applying the Law of Large Numbers applied to a subsequence of the Radamacher functions. When the discrete time distributions of the finite forms are identical for μ-almost all $x_0 \in X$ the weighted sum of the discrete time distributions reduces to the single valued distribution for any one of the finite forms. (Received September 21, 2010)

1067-37-1596 **Barry Alan Peratt*** (bperatt@winona.edu), Department of Math/Stats, Winona State University, 175 West Mark Street, Winona, MN 55987, and **Judy A. Kennedy** (kennedy9905@gmail.com), Department of Mathematics, Lamar University, PO Box 10047, Beaumont, TX 77710. *The Topology of Tank Stirring.*

We examine the topology of stirring in a cylindrical tank with a centrally located impeller and a recycle loop. In constrast to the usual approaches involving partial differential equations or statistical mechanics, we consider an idealized mathematical model which consists of a geometrically motivated discrete time process. Our numerical studies indicate the existence of invariant tori, corresponding to periodic orbits, within which no mixing occurs. In addition to rigorously proving the existence of such tori, we prove that, under certain mild conditions, the topological structure which evolves is a "Sierpinski-like" curve $\times S^1$. (Received September 21, 2010)

1067-37-1608 **Katie T Liszewski*** (ktliszew@ncsu.edu). *The charged free boson integrable hierarchy.*

Classical integrable hierarchies, such as the KP and Toda hierarchies, have an algebraic construction, which relies on the boson-fermion correspondence, an isomorphism between the fermionic and bosonic Fock spaces. Analogously, the representation of gl_∞ formed by two charged free bosons can be identified with a bosonic Fock space via the Friedan-Martinec-Shenker bosonization. We construct the corresponding charged free boson integrable hierarchy and show that it has many of the properties of the classical hierarchies. (Received September 21, 2010)

1067-37-1693 **Mark DeSantis*** (mjd34@pitt.edu), 301 Thackeray Hall, Pittsburgh, PA 15260. *Asset Price Dynamics: Differential Equations and Instability.*

Recent events have demonstrated the importance of studying asset prices through a dynamical systems model that allows for a variety of price-influencing factors. Our large-scale statistical data studies provide evidence for the inclusion of these factors. This system of differential equations admits a one-dimensional curve of equilibria. Local stability analysis is achieved via the Routh-Hurwitz criterion, which shows the existence of parameter regimes that yield stable and unstable regions of equilibria. From a global perspective, numerical studies have shown trajectories may take large "excursions" from unstable to stable equilibrium points. These large price excursions can be used as a new tool for studying risk. (Received September 21, 2010)

1067-37-1755 **Alica Miller***, Department of Mathematics, University of Louisville, Louisville, KY 40292. *Properties of a semiflow related to the integers.*

Let $M_2(\mathbb{Z})$ be the set of all objects of the form $(a\mathbb{Z})X^mY^n$, where a, m, n are integers, $m, n \geq 0$, X, Y variables. We define an operation on $M_2(\mathbb{Z})$ by putting

$$(a\mathbb{Z})X^mY^n \cdot (b\mathbb{Z})X^pY^q = (\mathrm{lcm}(a,b)\mathbb{Z})X^{m+p}Y^{n+q}.$$

With this operation $M_2(\mathbb{Z})$ becomes a semigroup. When naturally acting on itself, it defines a semiflow. We characterize subsemiflows of this semiflow and relate them to some properties of integers. (Received September 21, 2010)

1067-37-1874 **Michel L. Lapidus** (lapidus@ucr.edu), 900 Big Springs Rd., Surge Building, Math dept., Riverside, CA 92521, and **Robert G. Niemeyer*** (niemeyer@math.ucr.edu), 900 Big Springs Rd., Surge Building, Math dept., Riverside, CA 92521. *Families of periodic orbits of fractal billiard tables.*

The Koch snowflake fractal curve KS may be described as an inverse limit of prefractal approximations KS_n. Such a curve is non-differentiable and reflection in KS is not well defined. In light of the fact that KS can be described as an inverse limit, we describe orbits of the Koch snowflake fractal billiard $\Omega(KS)$ as inverse limits of particular inverse limit sequences of periodic orbits of the Koch snowflake prefractal billiards $\Omega(KS_n)$.

In addition, we extend the inverse limit construction of periodic orbits to other fractal billiards. In particular, we show that our results on $\Omega(KS)$ generalize to other billiard tables that may be described by particular iterated function systems.

We provide a formula for the lengths of particular families of periodic orbits of the fractal billiards discussed and show how, in the case of the Koch snowflake fractal billiard, that such a formula is intimately tied to the initial basepoint of an orbit of the equilateral triangle billiard $\Omega(KS_0)$.

We finish this talk by detailing conjectures on the existence of what we have termed 'fractal flat surfaces' and the relationship between the billiard flow and geodesic flow (both yet to be determined and fully defined). (Received September 22, 2010)

1067-37-1881 **James Cannon**, **Mark Meilstrup*** (markmeilstrup@gmail.com) and **Andreas Zastrow**. *The period set of a map from the Cantor set to itself.*

Let f denote a map from the Cantor set C to itself. If $x \in C$ and if there is a positive integer m such that $f^m(x) = x$, then we call x a periodic point of f. If m is the least such integer, then we call m the period of x and write $p(x) = m$. We define the period set of f to be the collection $P(f) = \{p(x) : x \text{ is periodic}\}$.

Because the Cantor set C is the most flexible of all compact metric spaces with an interesting topology, we would expect the period sets of its self-maps to be completely unrestricted. We prove this to be the case provided that, in addition, one allows points that are not periodic.

However, if every point x is periodic, we show that a surprising finiteness condition is imposed on $P(f)$: namely, there is a finite subset B of $P(f)$ such that every element of $P(f)$ is divisible by at least one element of B. (Received September 22, 2010)

1067-37-1934 **Kevin McGoff*** (mcgoff@math.umd.edu), Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20910. *Random Subshifts of Finite Type.*

A dynamical system consists of a space and a rule for how points move through space as time progresses. In this talk, we give an introduction to a class of discrete dynamical systems called subshifts of finite type (SFTs). We survey some of the characteristics of SFTs, and finally we discuss some recent results on likely properties of SFTs that have been "chosen at random," described below.

Let X be an irreducible shift of finite type (SFT) of positive entropy, and let $B_n(X)$ be its set of words of length n. Define a random subset ω of $B_n(X)$ by independently choosing each word from $B_n(X)$ with some probability α. Let X_ω be the (random) SFT built from the set ω. For each $0 \leq \alpha \leq 1$ and n tending to infinity, we compute the limit of the likelihood that X_ω is empty, as well as the limiting distribution of entropy for X_ω. For α near 1 and n tending to infinity, we show that the likelihood that X_ω contains a unique irreducible component of positive entropy converges exponentially to 1. (Received September 22, 2010)

1067-37-2072 **James A. Yorke*** (yorke@umd.edu), Dept of Mathematics, Univ. of Maryland, College Park, MD 20742. *Period doubling cascades for ordinary differential equations.* Preliminary report.

This is joint work with Evelyn Sander. We developed a theory of cascades that enables us to get conclusions for differential equations in the plane, such as the forced damped pendulum and forced damped Duffing equation. This work is topological and connects cascades to the development of chaos. This theory will be contrasted with the scaling theory of cascades that began with the work of M Feigenbaum. (Received September 22, 2010)

1067-37-2116 **Rika Hagihara*** (rhagihara@smcm.edu), Mathematics and Computer Science, St. Mary's College of Maryland, St. Mary's City, MD 20686-3001, and **Jane Hawkins** (jmh@math.unc.edu), Mathematics Department, CB#3250, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599. *Dynamics of degree 3 rational maps with parabolic fixed points.* Preliminary report.

We study families of degree 3 rational maps of the sphere with the property that each map has at least one fixed point with multiplier -1. We discuss the interplay between their parameter spaces and the dynamical planes. We compare the parameter spaces with the Mandelbrot set. (Received September 22, 2010)

1067-37-2282 **Brett M. Werner*** (brett.werner@uni.edu), 1227 W. 27th St, Cedar Falls, IA 50614. *Strong Orbit Equivalence and Residuality.*

In the category of minimal Cantor systems, there are several notions of equivalence. One such equivalence is strong orbit equivalence. In 1995, Giordano, Putnam, and Skau introduced this notion showing that two systems are strongly orbit equivalent if and only if their associated dimension groups are order isomorphic which is also equivalent to their associated C*-algebras being isomorphic. It is a common question to ask what systems are generic within this equivalence class. Some questions regarding this question will be answered. In particular, the set of systems with zero entropy in these strong equivalence classes are residual. (Received September 22, 2010)

1067-37-2287 **Nishu Lal*** (nishul@math.ucr.edu), Department of Mathematics, University of California, Riverside, 261 Surge Building, Riverside, CA 92521, and **Michel Lapidus** (lapidus@math.ucr.edu), Department of Mathematics, University of California, Riverside, 231 Surge Building, Riverside, CA 92521. *Product structure of the spectral zeta function of the Sturm-Liouville operator on fractals.* Preliminary report.

In this talk, we will discuss the spectral zeta function of a self-similar Sturm-Liouville operator on the half real line and C. Sabot's work on connecting the spectrum of this operator with the iteration of a rational map of several complex variables. The Sturm-Liouville operator on $[0,\infty)$ is viewed as a limit of the sequence of operators $\frac{d}{dm_{<n>}}\frac{d}{dx}$ with Dirichlet boundary condition on $I_{<n>} = [0,\alpha^{-n}]$ which are the infinitesimal generators of the Dirichlet form $(a_{<n>}, m_{<n>})$. In particular, it is defined in terms of a self-similar measure m and Dirichlet form a, relative to a suitable iterated function system (IFS) on $I = [0,1]$. In the case of the Sierpinski gasket, as was shown by A. Teplyaev, extending the known relation by M. Lapidus for fractal strings, the spectral zeta function of the Laplacian has a product structure with respect to the iteration of a rational map on $\mathbb{C}$ which arises from the decimation method. In the case of the above self-similar Sturm-Liouville problem, we obtain an analogous product formula, but now expressed in terms of the (suitably defined) zeta function associated with the dynamics of the corresponding 'renormalization map', viewed as a rational function on $\mathbb{P}^2(\mathbb{C})$. (Received September 22, 2010)

39 ► Difference and functional equations

1067-39-16 **Robert R. Ferdinand*** (rferdand@ecok.edu), PMB K-1, 1100 East 14th Street, Ada, OK 74820, and **Matthew M. Donica**, **James K. Gordon**, **Laura E. Johnson** and **Jessica L. Pitts**. *Modeling Interactions Among Fish, Fishermen and Fish-Eating Bird Populations.*

A coupled system of three nonlinear difference equations is presented. This system models the dynamics of interactions among fish, fishermen (men and women) and fish-eating bird populations in a water body such as a lake. Fixed points of this model are calculated and their stability is analyzed. Finally a numerical example is presented which graphically illustrates the theoretical results proved. Mathematica software is used to obtain the graphical results. This research involves four undergraduate mathematics majors and is sponsored by the 2009-2010 Center for Undergraduate Research in Mathematics (CURM) Grant. CURM is funded by the National Science Foundation (NSF) via DMS Grant # 0636648 and Brigham Young University (BYU). (Received August 19, 2010)

1067-39-18 **Johnny Henderson*** (Johnny_Henderson@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798-7328. *Right focal boundary value problems for difference equations.*

An application is made of a new fixed point theorem of compression and expansion functional type in the spirit of the original fixed point work of Leggett and Williams, to obtain positive solutions of the second order right focal discrete boundary value problem. In the application of the fixed point theorem, neither the entire lower nor entire upper boundary is required to be mapped inward or outward. An example is also provided. (Received May 11, 2010)

1067-39-122 **George A. Anastassiou*** (ganastss@memphis.edu), Department of Mathematical Sciences, Memphis, TN 38152. *Foundations of Nabla Fractional Calculus on Time Scales and Inequalities.* Preliminary report.

Here we develop the Nabla Fractional Calculus on Time Scales. Then we produce related integral inequalities of types: Poincaré, Sobolev, Opial, Ostrowski and Hilbert-Pachpatte. Finally we give inequalities applications on the time scales R,Z. (Received July 25, 2010)

1067-39-195 **Mojtaba Moniri*** (m-moniri@wiu.edu), Department of Mathematics, Western Illinois University, Macomb, IL 61455. *Systems of Difference Equations, Oscillations, and Sturmian Sequences.* Preliminary report.

We consider certain matrix difference equations, where the eigenvalues of the 2×2 transition matrix are distinct. As usual, diagonalization gives the solution involving (the real and imaginary parts of) powers of an eigenvalue

λ. Whether the argument $\alpha > 0$ of λ is an irrational multiple of π and whether $|\lambda| > 1$, $= 1$, or < 1, govern the type of long-term behavior. Various cases are illustrated when the starting values compare differently with the equilibrium values. Plane quadrants where each component of the solution is increasing/decreasing and is greater/less than its counterpart in the equilibrium are identified. Actually when both starting values are different from such counterparts, the quadrants are obtained from the ordinary ones via a certain rotation. These are implied by the Beatty sequence $\lfloor n\alpha \rfloor$, and in the latter case by the more general Sturmian sequence $\lfloor \gamma + n\alpha \rfloor$, $n \in \mathbb{N}$, where γ is described. Anyone who ever built numerical solutions to such systems and wondered why, for some k, they oscillated every k or $k-1$ terms, now sees how k relates to α. (Received July 31, 2010)

1067-39-211 **Gerasimos E Ladas*** (gladas@math.uri.edu), University of Rhode Island, Department of Mathematics, Kingston, RI 02881. *Open Problems and Conjectures in Difference Equations.* Preliminary report.

We present some new results and we pose several open problems and conjectures on the global character of solutions of rational difference equations and systems of rational difference equations. We are interested in patterns of boundedness, invariants, global stability results, periodic solutions, convergence to periodic solutions, and periodic trichotomies. During the last two years with my collaborators and students we have discovered 15 patterns of boundedness for rational systems in the plane which (with a few conjectures about a small number of special cases) determine the boundedness character of each of the 2401 special cases of rational systems in the plane. Thses patterns offer a fertile area of research in the global character of solutions of rational difference equations and systems. (Received August 04, 2010)

1067-39-300 **Fatma Karakoc*** (karakoc@science.ankara.edu.tr), Ankara University, Faculty of Science, Department of Mathematics, Tandogan, 06100 Ankara, Turkey, and **Huseyin Bereketoglu** and **Gizem Seyhan**. *Oscillation of Impulsive Differential Equations with Piecewise Constant Argument.*

The systematical studies with mathematical models involving piecewise constant arguments were initiated for solving some biomedical problems such as sequential-continuous models of disease dynamics. In this work, we investigate a linear impulsive delay differential equation with piecewise constant argument. We obtain some conditions for the existence and uniqueness of the solutions. Moreover, oscillation, nonoscillation and periodicity of the solutions are studied. (Received August 18, 2010)

1067-39-301 **Huseyin Bereketoglu*** (bereket@science.ankara.edu.tr), Ankara University, Faculty of Science, Department of Mathematics, Tandogan, 06100 Ankara, Turkey, and **Aydin Huseynov**. *Convergence of Solutions of Nonhomogeneous Linear Difference Systems with Delays.*

Sufficient conditions are given for the asymptotic constancy of the solutions of a linear system of difference equations with delays. Moreover, it is shown that the limits of the solutions, as t goes to infinity, can be computed in terms of the initial function and a special matrix solution of the corresponding adjoint equation. (Received August 18, 2010)

1067-39-445 **Ziyad AlSharawi*** (alsha1zm@alsharawi.info), Department of Mathematics & Statistics, Sultan Qaboos University, PC 123 Al-Khoud, Muscat, Oman, and **R. Abu-Saris** and **M. Rhouma**. *The dynamics of Pielou's equation under the effect of harvesting.* Preliminary report.

In this talk, we discuss the dynamics of Pielou's equation $x_{n+1} = \frac{K\mu x_n}{K+(\mu-1)x_{n-t}} - h(x_n, \ldots, x_{n-t})$.

When $t = 0$, we obtain the Beverton-Holt model, and some results concerning periodic harvesting in periodically fluctuating environment will be given. When $t = 1$, we discuss some characteristics of persistent solutions and the persistent set, particularly when $h(x_n, \ldots, x_{n-t})$ is constant or proportional to x_n, x_{n-1}. Also, some comparison between the various scenarios will be given. (Received September 03, 2010)

1067-39-484 **Vlajko L Kocic*** (vkocic@xula.edu), Mathematics Derpartment, Xavier University of Louisiana, 1 Drexel Dr., New Orleans, LA 70125. *Global Behavior of Certain Nonautonomous Nonlinear Discrete Population Models Exhibiting Allee Effect.* Preliminary report.

Boundedness, extreme stability, existence and the stability character of periodic solutions of certain classes of nonautonomous nonlinear discrete population models exhibiting Allee effect is studied. In particular the dynamics of periodically forced population models is considered. (Received September 06, 2010)

1067-39-486 **Vlajko L Kocic*** (vkocic@xula.edu), Mathematics Derpartment, Xavier University of Louisiana, 1 Drexel Dr., New Orleans, LA 70125. *Attenuance and Resonance of Periodic Cycles in Some Periodically Forced Population Models.* Preliminary report.

Attenuance and resonance of periodic cycles in certain classes of periodically forced population models is studied. (Received September 22, 2010)

1067-39-501 **Michael Holm*** (s-mholm3@math.unl.edu), 2520 S. 37th St., Lincoln, NE 68506. *The Laplace Transform in Discrete Fractional Calculus.*

The Discrete Laplace Transform is the integer-special case of the general Laplace Transform developed in the theory of time scales. We develop properties of this transform in the fractional calculus setting, giving a precise treatment to domains of convergence along the way. Our goal is to apply the Laplace Transform Method to solve a general fractional initial value problem. (Received September 07, 2010)

1067-39-627 **Sukanya Basu*** (sukanya.basu@mwsu.edu), 3410 Taft Blvd., Wichita Falls, TX 76308. *Global Attractivity of Equilibria and Existence of Prime Period-Two Solutions for a Class of Planar Systems of Difference Equations.*

For nonnegative parameters α_1, β_1, γ_1, A_1, B_1, C_1, α_2, β_2, γ_2, A_2, B_2 and C_2, consider the system of first-order rational difference equations

$$\left.\begin{aligned} x_{n+1} &= \frac{\alpha_1 + \beta_1\, x_n + \gamma_1\, y_n}{A_1 + B_1\, x_n + C_1\, y_n} \\ y_{n+1} &= \frac{\alpha_2 + \beta_2\, x_n + \gamma_2\, y_n}{A_2 + B_2\, x_n + C_2\, y_n} \end{aligned}\right\}, \quad n = 0, 1, 2, \ldots \tag{1}$$

where

$$\alpha_i + \beta_i + \gamma_i > 0 \qquad \text{and} \qquad A_i + B_i + C_i > 0 \quad \text{for} \quad i = 1, 2.$$

System (1) consists of 2401 individual planar systems of first-order rational difference equations which include the Leslie-Gower Model from theoretical ecology analyzed by Cushing et. al. in 2006. I will talk about the global behavior of solutions, stability of equilibria and existence of prime period-two solutions for certain subclasses of (1). (Received September 12, 2010)

1067-39-632 **Lih-Ing Wu Roeger*** (lih-ing.roeger@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *Two Peas in a Pod: Discrete and Continuous Lotka-Volterra Competition Systems.* Preliminary report.

Discrete-time competition systems that are dynamically consistent with the continuous-time Lotka-Volterra competition system, $x' = x(r_1 - a_{11}x - a_{12}y)$, $y' = y(r_2 - a_{21}x - a_{22}y)$, will be presented. Similar dynamics include: the positivity of solutions, the local and global stability of the equilibria, and the monotonicity of the systems. The discrete system is derived from the continuous system by nonstandard finite difference schemes (NSFD). (Received September 12, 2010)

1067-39-670 **Saber N Elaydi*** (selaydi@trinity.edu), One Trinity Place, San antonio, TX 78212. *Bifurcation and stability of a Ricker-type competition model.* Preliminary report.

We will present a bifurcation analysis of a discrete competition model of Ricker type. Moreover, a complete analysis of the associated invariant manifolds, including cenere,stable, and unstable manifolds will be presented. (Received September 13, 2010)

1067-39-680 **Saber N Elaydi*** (selaydi@trinity.edu), One Trinity Place, San antonio, TX 78212. *Stability and bifurcation of a discrete logistic competition model.* Preliminary report.

We will investigate the stability and bifurcation of a new logistic type competition model. Then we will determine the invariant manifolds, including stable, unstable and center manifolds. (Received September 13, 2010)

1067-39-754 **Chris R Ahrendt*** (ahrendcr@uwec.edu), University of Wisconsin-Eau Claire, Department of Mathematics, Hibbard Hall 525, Eau Claire, WI 54701. *Recursive Representations for the Unique Solution of the Transport Equation on Isolated Time Scales.*

In this talk, we will develop two recursive representations for the unique solution of the transport partial dynamic equation on an isolated time scale. We will then use these representations to explicitly find the solution of the transport equation in several specific cases. Finally, we will compare and contrast the behavior with that of the well-known behavior of the solution to the transport partial difference equation in the case where $\mathbb{T} = \mathbb{Z}$. (Received September 14, 2010)

1067-39-814 **Heidi Berger*** (heidi.berger@simpson.edu), 701 N. C Street, Indianola, IA 50125, and **Jo Hoffacker** and **Raegan Siwatu**. *A time scales model of competition in the southern pine beetle, Dendroctonus frontalis.* Preliminary report.

Two models for competition in the southern pine beetle are examined, first assuming regularly spaced generations in the beetle and also using generational spacing based on accumulated degree day measurements. The role of the graininess in this model will be discussed using data from an infestation in Kisatchie National Forest, Louisiana in the 1990s. (Received September 15, 2010)

1067-39-988 **H Sedaghat*** (hsedagha@vcu.edu), Department of Mathematics, Virginia Commonwealth University, Box 842014, Richmond, VA 23284-2014. *Uncovering fundamental properties of difference equations by semiconjugate factorization.*

It is often possible to gain substantial insight into the nature of a higher order difference equation and the behavior of its solutions by analyzing its structure of the equation itself and uncovering hidden symmetries in its form. I use the method of semiconjugate factorization to decompose a difference equation of order two or greater into a triangular system of two lower order equations. Then apply this method to linear difference equations and, time-permitting some nonlinear ones as well. In the linear case, the above method casts new light on familiar concepts such as eigenvalues and the role of the homogeneous part in obtaining a solution. It also adds new information, e.g., on the role of the discrete Riccati equation as a catalyst for possible decompositions of linear equations on a given algebraic field. (Received September 17, 2010)

1067-39-997 **Flavia Stan*** (fstan@risc.jku.at). *Computing recurrences for Mellin-Barnes integrals.*

We present how Wilf-Zeilberger summation methods can be used to determine homogeneous and inhomogeneous recurrences for multiple Mellin-Barnes integrals where in analogy to the summation case, the integrands need to be hypergeometric in all integration variables and contain free hypergeometric parameters.

These complex contour integrals can also be viewed as sums of residues at certain poles of the integrands and they are connected to the inversion formula for the Mellin transform. Our algorithmic approach for computing the difference equations they satisfy, eliminates the need to search for sum representations and has several interesting applications. (Received September 17, 2010)

1067-39-1069 **Priscilla Supnet Macansantos*** (pmacansantos@yahoo.com), University of the Philippines Baguio, Governor Pack Road, 2600 Baguio City, Philippines. *Existence Theorem for Set-Valued Differential Inclusion Using the Pseudo-integral in Pseudo-analysis.* Preliminary report.

The theory of set-valued functions and the arising differential inclusions is now an important tool in applications, particularly in economics. The initial definition for the integral of a set-valued function is due to Aumann, and this is a generalization of the integral of a point-valued function, using the idea of selections. In recent years, the area of pseudo-analysis was developed by E. Pap, et al, to further generalize concepts in analysis, such as integration, via the use of a semiring structure and generated measures. A pseudo-integral of a set-valued function was defined by Tatjana Grbic et al, and we use this to study an existence theorem for differential inclusions. Under generalized analogous conditions on the set valued function that defines the inclusion ("semicontinuity," boundedness), existence of a solution is proven. (Received September 17, 2010)

1067-39-1154 **Mahmoud H. Annaby***, Department of Math., Stat. & Phy., Qatar University, Doha, 2713, Qatar, and **Hassan A. Hassan** and **Zeinab S. Mansour**. *Sampling theorems associated with Singular Basic Sturm Liouville Problems.*

Sampling theorems for transformations defined in terms of Jackson q-integration when the kernels of the transformations are solutions or the Green's functions of singular q-Sturm–Liouville problems are investigated. We consider the problem when the q-Sturm–Liouville problem is singular either at infinity or zero with detailed investigations when the singular point is infinity. An example involving combinations of Jackson $q-$Bessel function is given. (Received September 19, 2010)

1067-39-1238 **Ann Brett***, Department of Mathematics, Kingston, RI 02881. *Basins of Attraction of Equilibrium Points of Monotone Difference Equations.*

We investigate the global character of the difference equation of the form

$$x_{n+1} = f(x_n, x_{n-1}, \dots, x_{n-k+1}), \quad n = 0, 1, \dots$$

with several equilibrium points, where f is increasing in all its variables. We show that the boundaries of the basins of attractions of different locally asymptotically stable equilibrium points are in fact the global stable manifolds of neighboring saddle or non-hyperbolic equilibrium points. (Received September 20, 2010)

1067-39-1251 **M. R. S. Kulenovic*** (mkulenovic@mail.uri.edu), Department of Mathematics, Lippitt Hall, Kingston, RI 02881. *Invariant Manifolds for Competitive Discrete Systems in the Plane - Non-hyperbolic Case.*

Let T be a competitive map on a rectangular region $\mathcal{R} \subset \mathbb{R}^2$, and assume T is C^1 in a neighborhood of a fixed point $\overline{x} \in \mathcal{R}$. We present the results which give conditions on T that guarantee the existence of an invariant curve emanating from $\overline{x}$ when both eigenvalues of the Jacobian of T at $\overline{x}$ are nonzero and at least one of them has absolute value less than one, and establish that $\mathcal{C}$ is an increasing curve that separates $\mathcal{R}$ into invariant regions. We emphasize the importance of this result in non-hyperbolic cases, and show that it can be effectively used to determine basins of attraction of fixed points of competitive maps, or equivalently, of equilibria of competitive systems of difference equations. The emphasis in applications in this paper is to planar systems of difference equations with non-hyperbolic equilibria, where we establish a precise description of the basins of attraction of finite or infinite number of equilibrium points. (Received September 20, 2010)

1067-39-1375 **Candace M. Kent*** (cmkent@vcu.edu), Dept. of Mathematics and Applied Mathematics, Grace E.Harris Hall, 1015 Floyd Avenue, P.O. Box 842014, Richmond, VA 23284-2014, and **Witold Kosmala** and **Stevo Stevic**. *Long-Term Behavior of Solutions of the Difference Equation $x_{n+1} = x_{n-1}x_{n-2} - 1$.*

We investigate the long-term behavior of solutions of the following difference equation:

$$x_{n+1} = x_{n-1}x_{n-2} - 1, \quad n \in \mathbf{N_0},$$

where the initial conditions x_{-2}, x_{-1}, x_0 are real numbers. Numerous fascinating properties of the solutions of the equation are presented. (Received September 20, 2010)

1067-39-1617 **Tamara Yevgenia Awerbuch*** (tamara@hsph.harvard.edu), Dept. of Population and International Health, 655 Huntington Ave, Boston, MA 02115, **Richard Levins** (humaneco@hsph.harvard.edu), Depart. of Population and International Healt, 655 Huntington Ave, Boston, MA 02115, **Michael A Radin** (michael.radin@rit.edu), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester, NY 14623, **Candace M Kent** (cmkent@vcu.edu), Richmond, VA , and **Vlajko Kocic** (vkocic@xula.edu), New Orleans, LA. *Applications of System of Logistic Difference Equations in agriculture.*

We will investigate the following system of Logistic Difference Equations:

Xn+1 = r1yn(1-yn) Yn+1=r2xn (1-xn)

where, 0 <r1,r2 <4; in particular, the convergence nature, the periodic nature and the chaotic nature of solutions. In addition, we will discuss the origin of it in applications in agriculture. We will also illustrate some computer simulations. (Received September 21, 2010)

1067-39-1634 **Ross A Chiquet*** (rchiquet@louisiana.edu), 217 Maxim D. Doucet Hall, P.O.Box 41010, P.O.Box 41010, Lafayette, LA 70504-1010, and **Azmy S Ackleh**. *Competitive exclusion in a discrete juvenile-adult model with continuous and seasonal reproduction.*

We develop a general discrete juvenile-adult population model that describes two competing species. We consider species in which the juveniles only compete with other juveniles, and the adults only compete with other adults, i.e. juveniles and adults of either species do not compete. This is typical of amphibians where juveniles (tadpoles) live in water and adults (frogs) live on land. Assuming competition efficiencies of the two species are similar, we analyse the cases where reproduction is either continuous or seasonal. In both cases, we develop conditions on the invasion net reproductive numbers of the two species that will lead to competitive exclusion. We show using numerical simulations that coexistence and bistability are possible outcomes when competition efficiencies of the two species are different. (Received September 21, 2010)

1067-39-1690 **Ruth D Enoch*** (renoch@atu.edu), Arkansas Tech University, Department of Mathematics, 1811 North Boulder Avenue, Russellville, AR 72801-2222. *Formal power series solutions of Schröder's functional equation.*

In 1884, Königs showed that when $\varphi(z)$ is an analytic self-map of the unit disk fixing the origin, with $0 < |\varphi'(0)| < 1$, then Schröder's functional equation, $\psi \circ \varphi(z) = \varphi'(0)\psi(z)$, can be solved for a unique analytic function $\psi(z)$ in the disk with $\psi'(0) = 1$. In 2003, Cowen and MacCluer considered an analogue in the unit ball of $\mathbb{C}^N$ for $N > 1$. They gave necessary and sufficient conditions for the existence of an analytic solution σ satisfying $\sigma'(0) = I$ when $\varphi'(0)$ is diagonalizable. In 2006, Enoch considered the case in which $\varphi'(0)$ is not diagonalizable. Both $\varphi(z)$ and $\sigma(z)$ are regarded as vectors of purely formal power series, and it is not assumed that $\varphi(z)$ is analytic or that the series for $\varphi(z)$ or $\sigma(z)$ converge. However, because of a process developed by Cowen and MacCluer, if the given $\varphi(z)$ represents a map of the unit ball into itself of an appropriate form, then Enoch's results can be used to produce solutions of Schröder's equation that are convergent power series, or (sometimes) to show that no such solution exists. A method of matrix completion is used. (Received September 21, 2010)

1067-39-1731 **Orlando Merino*** (merino@math.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *On invariant curves of certain nonhyperbolic equilibria of planar competitive systems.*

We discuss invariant curves associated to nonhyperbolic equilibria of planar competitive systems, including stable and center manifolds. (Received September 21, 2010)

1067-39-1780 **H Sedaghat*** (hsedagha@vcu.edu), Department of Mathematics, Virginia Commonwealth Unviersity, Box 842014, Richmond, VA 23284-2014. *Reducing the order of a second-order difference equation with application to a biological model.*

Under certain conditions on parameters a second-order difference equation of type

$$x_{n+1} = x_n^{a_0} x_{n-1}^{a_1} e^{\alpha_n - b_0 x_n - b_1 x_{n-1}}$$

can be decomposed or factored into a system of two first-order difference equations. I explore these conditions generally for higher order difference equations and then use the results to determine the global dynamics of solutions in the plane of a special case of the above equation that appears in a biological population model. (Received September 21, 2010)

1067-39-2064 **Yongjae Cha*** (ycha@math.fsu.edu), FSU Mathematics, 208 Love Building 1017 Academic Way, Tallahassee, FL 32306. *Local data of a Linear Difference Operator.*

In a recent paper we gave an algorithm to find closed form solutions for linear recurrence equations. The key ingredient needed for this algorithm is local data at singularities. The topic of this talk will be how to compute this local data which involves computing valuation, Newton polygon and indicial equation of a linear difference operator. (Received September 22, 2010)

1067-39-2066 **Y Kostrov*** (ykostrov@xula.edu), 1329 Saint Andrew st, apt 2, new orleans, LA 70130. *On the periodically forced Simoid Beverton-Holt Model.* Preliminary report.

We study the attanuance of the solutions of the periodically forced Simoid Beverton-Holt Model (Received September 22, 2010)

1067-39-2089 **Jairo Santanilla***, 2000 Lakeshore Dr., University of New Orleans, Department of Mathematics, New Orleans, LA 70148. *A system of Stochastic Difference Equations Modeling Terrorism.* Preliminary report.

In recent years there has been a great deal of interest in applications of the classical Lanchester equations to terrorism modeling. These equations have been improved by considering a system of stochastic differential equations. In this talk we consider a system of stochastic differential equations modeling terrorism and transform this system to one of stochastic difference equations. (Received September 22, 2010)

1067-39-2141 **Kristen Abernathy*** (kekobylu@ncsu.edu) and **Jesus Rodriguez**. *Non-local boundary value problems for discrete systems.*

Our goal in this talk is to provide sufficient conditions for the existence of solutions to discrete, nonlinear systems of the form

$$y(k+n) + \cdots + a_0(k)y(k) = f(y(k)) + \sum_{l=0}^{J} w(k,l)g(l, y(l), \cdots, y(l+n-1))$$

subject to the multipoint boundary conditions

$$\sum_{j=1}^{n} b_{ij}(0)y(j-1) + \sum_{j=1}^{n} b_{ij}(1)y(j) + \cdots + \sum_{j=1}^{n} b_{ij}(J)y(j+J-1) = 0$$

for $i = 1, 2, \cdots, n$. The criteria we present depends on the size of the nonlinearity and the set of solutions to the corresponding linear, homogeneous boundary value problems. Our analysis is based on the Lyapunov-Schmidt Procedure and Brouwer's Fixed Point Theorem. The results presented extend the previous work of J. Rodriguez and P. Taylor and D. Etheridge and J. Rodriguez. (Received September 22, 2010)

1067-39-2341 **Jesus Rodriguez** and **Zachary Abernathy*** (zjaberna@ncsu.edu). *Nonlinear Discrete Sturm-Liouville Problems with Global Boundary Conditions.*

This talk shall be devoted to the study of nonlinear difference equations subject to global nonlinear boundary conditions. We provide sufficient conditions for the existence of solutions based on properties of the nonlinearities and the eigenvalues of an associated linear Sturm-Liouville problem. We shall rewrite the nonlinear boundary value problem as an operator equation of the form

$$\mathcal{L}x - \Psi x = \mathcal{G}x.$$

The study of equations of this form has been frequent in the literature, where $\mathcal{L}$ is a linear differential expression, Ψ is a continuously Fréchet differentiable operator, and $\mathcal{G}$ is an operator with bounded range. For example, the case when $\mathcal{L}$ is an ordinary differential operator has been studied extensively by authors such as Lazer, Leach, Sanchez, Brown, and Lin. Landesman and Lazer considered the case when $\mathcal{L}$ is a self adjoint partial differential operator. Our formulation of the operator equation incorporates both the dynamics and the boundary conditions, and the non-local boundary conditions are significantly more general than those that have previously appeared in the above-mentioned analogous results for differential equations. (Received September 22, 2010)

1067-39-2404 **Austin H Jones***, Department of Mathematics, Wake Forest University, Winston-Salem, NC 27109, and **Kenneth S Berenhaut**, Department of Mathematics, Wake Forest University, Winston-Salem, NC 27109. *Asymptotic behavior of solutions to difference equations involving ratios of elementary symmetric polynomials.*

This paper studies the behavior of positive solutions of the recursive equation $y_n = \left(\frac{e_{i,k}}{e_{j,k}}\right)(y_{n-t_1}, y_{n-t_2}, \ldots, y_{n-t_k})$, $0 \leq i, j \leq k$, where $e_{m,k}$ is the m^{th} elementary symmetric polynomial on k variables, $t_l \geq 1$ for $1 \leq l \leq k$, $\gcd(t_1, t_2, \ldots, t_k) = 1$ and $y_{-s}, y_{-s+1}, \ldots, y_{-1} \in \mathbb{R}^+$, with $s = \max\{t_1, t_2, \ldots, t_k\}$. A variant of Newton's inequalities is employed. Included amongst the results is a generalization of a particular case of Theorem 4.11 in E. A. Grove and G. Ladas, *Periodicities in Nonlinear Difference Equations*, Chapman & Hall/CRC Press, Boca Raton (2004). (Received September 23, 2010)

40 ► Sequences, series, summability

1067-40-674 **Burcin Erocal*** (burcin@erocal.org), Johannes Kepler University, RISC, Altenbergerstr. 69, A-4040 Linz, Austria. *Algebraic Extensions for Summation in Finite Terms.*

The summation analogue of the Risch algorithm for indefinite integration was developed by Michael Karr based on towers of specialized difference fields called $\Pi\Sigma$ fields. In contrast to algorithms for indefinite integration, only transcendental extensions are allowed in these towers since algebraic extensions may force one to work over rings with zero divisors. This limits the set of expressions which can be modeled by $\Pi\Sigma$ fields. For example extensions involving $(-1)^n$ is outside the scope of Karr's algorithm. We present a new approach to this problem which allows us to have algebraic extensions in towers. This leads to effective algorithms extending the capabilities of Karr's algorithm. (Received September 13, 2010)

1067-40-1193 **Thomas J. Osler*** (osler@rowan.edu), Mathematics Department, Rowan University, Glassboro, NJ 08028. *Expressions with pi and the lemniscate constant expanded as infinite products and continued fractions.*

The lemniscate constant L is defined as half the perimeter of the lemniscate curve r ^{2} = cos(2 theta). This number shares some features of the number pi. Recently Stedall [2] showed that the famous continued fraction for pi of Lord Brouncker is only one of an infinite sequence of continued fractions that he had discovered and that seem to have been forgotten in recent times. This author wrote about them in [1]. In this paper we find another infinite sequence of continued fractions very closely related to Lord Brouncker's, only these converge to a rational function of L ^{2} /pi. Infinite products resembling the famous product of Wallis for pi are also found for these rational functions of L ^{2} /pi as well as for L itself. [1] Osler, Thomas J., Lord Brouncker's forgotten sequence of continued fractions for pi. International Journal of Mathematical Education in Science and Technology, Volume 41, Issue 1 January 2010 , pages 105 - 110. [2] Stedall, Jacqueline A., Catching Proteus: The Collaborations of Wallis and Brouncker. I. Squaring the Circle, Notes and Records of the Royal Society of London, Vol. 54, No. 3, (Sep., 2000), pp. 293 -316 (Received September 20, 2010)

1067-40-1231 **Flavia Stan*** (fstan@risc.jku.at). *A symbolic summation approach to Feynman integral calculus.*

We discuss new algorithmic strategies for multisums arising in the computation of Feynman parameter integrals and present examples of typical computations coming from the two-loop integrals.

Our procedure relies on rewriting Feynman parameter integrals as multisums over hypergeometric terms which fit the input class of summation algorithms. For these nested sums, WZ-summation methods deliver inhomogeneous recurrence relations. Recursively computing recurrences for the sums appearing in the inhomogeneous parts, we get recurrences which have only hypergeometric terms on their right hand sides.

For the next step of the method we use procedures from C. Schneider's Sigma package which solve these last inhomogeneous difference equations. Plugging in the answers into the recurrences from the previous level, we can recursively compute all solutions. At last we find alternative representations for the Feynman integrals with which we started, in terms of to harmonic sums.

This work is part of a collaboration with Carsten Schneider (RISC, J. Kepler University Linz, Austria) and Johannes Blümlein (DESY Zeuthen, Germany). (Received September 20, 2010)

1067-40-1448 **Jeff Connor*** (connorj@ohio.edu), Department of Mathematics, Ohio University, Athens, OH 45701, and **Hafize Gok**. *Results on asymptotically regular matrix methods.* Preliminary report.

Two sequences x and y are defined to be asymptotically equivalent if the $\lim_k (x_k/y_k) = 1$ and a summability matrix is defined to be *asymptotically regular* if it maps nonnegative asymptotically equivalent sequences to asymptotically equivalent sequences. Pobyvanets(1980) introduced asymptotically equivalent matrices and characterized nonnegative asymptotically regular matrices. More recently Marouf(1993) and Li(1997) have explored variations of the definition of asymptotically equivalent sequences and studied nonnegative matrices which preserve these variations. Given an ideal I of subsets of $\mathbb{N}$ that contains finite subsets, a sequence is said to be I-convergent to l provided $\{k : |x_k - l| \geq \varepsilon\} \in I$ for all $\varepsilon > 0$, and two nonnegative sequences x and y are said to be $I-$asymptotically equivalent provided x_n/y_n is I-convergent to 1. In this note, given ideals I and J, we characterize nonnegative matrices which map I-asymptotically equivalent sequences to J-asymptotically equivalent sequences and establish results analogous to those of Marouf and Li. The constraint that the summability matrix be nonnegative is also discussed. (Received September 21, 2010)

1067-40-1538 **Ovidiu Costin** and **Min Huang*** (huangm@math.uchicago.edu), Dept. of Mathematics, 5734 S. University Avenue, Chicago, IL 60637. *Applications of Transseries to the Geometry of Fractals.*

Fractals are fascinating geometric objects, having highly complicated and self-similar shapes. Among the most famous fractals are the Julia sets of quadratic maps. Here we present transseries formulas for the Julia sets corresponding to hyperbolic components of the Mandelbrot set. These formulas not only reveal the geometric structures of the fractals, but also provide a way to estimate their Hausdorff dimensions. (Received September 21, 2010)

1067-40-1626 **Ovidiu Costin*** (costin@math.ohio-state.edu), Math Tower, 231 W 18th Ave, Columbus, OH 43210. *Transseries, trans-analyticity and trans-transseries.*

I will discuss the importance of transseries in analysis and dynamical systems, focusing on the way they are summed to obtain general solutions of ODEs, PDEs and difference equations. I will also sketch what lies beyond the realm of transseries. (Received September 21, 2010)

1067-40-1950 **Lisa Lorentzen*** (lisa@math.ntnu.no), Department of Mathematics, NTNU, N-7491 Trondheim, Norway. *Convergence of continued fractions.* Preliminary report.

I have chosen an open title for this talk, since what I want to talk about is not quite finished, and I do not know for sure whether it will be finished by the time of the conference. But, whatever happens, I want to talk about something in the area of convergence of continued fractions. (Received September 22, 2010)

41 ► Approximations and expansions

1067-41-283 **Edward J. Fuselier*** (efuselie@highpoint.edu), 833 Montlieu Ave., High Point, NC 27262, and **Grady B. Wright**. *Scattered Data Interpolation on Embedded Submanifolds with Restricted Positive Definite Kernels: Sobolev Error Estimates.*

In this talk we will discuss the approximation properties of kernel interpolants on manifolds. The kernels we consider will be obtained by the restriction of positive definite kernels on $\mathbb{R}^d$, such as radial basis functions (RBFs), to a smooth, compact embedded submanifold $\mathbb{M} \subset \mathbb{R}^d$. For restricted kernels having finite smoothness, we will provide a complete characterization of the native space on $\mathbb{M}$. After this and some preliminary setup, we will present Sobolev-type error estimates for the interpolation problem. (Received August 16, 2010)

1067-41-298 **Jonathan M Borwein***, School of Math and Phys Sciences, University of Newcastle, Callaghan, NSW 2308, Australia, and **Armin Straub**, **James Wan** and **Wadim Zudilin**. *Densities of short uniform random walks.*

I present recent results on the densities, p_n, of n-step random uniform random walks in the plane. For $n \geq 7$ asymptotic formulas first developed by Raleigh are largely sufficient to describe the density. For $2 \leq n \leq 6$ this is far from true, as first investigated by Pearson. I shall give remarkable new hypergeometric closed forms for p_3, p_4 and precise analytic information for larger n.

This is joint work with Armin Straub, James Wan and Wadim Zudilin. (Received August 17, 2010)

1067-41-473 **Michael Schreiner*** (schreiner@ntb.ch), University of Buchs NTB, Institute for Computational Engineering, Werdenbergstrasse 4, CH-9471 Buchs, Switzerland. *Sphere Oriented Wavelets Based on Radial Basis Functions.*

Many applications require the approximation of functions on spheres or surfaces which are close to a sphere. Different multiresolution approaches for these situations are at hand. In many cases (e.g. for applications in geodesy), partial differential equations can be reduced to isotropic pseudo differential equations. The isotropy of the underlying operators correspond to isotropic kernels on the sphere. Thus, the use of multiresolution analysis techniques which are based on isotropic kernels, i.e. radial basis functions, are of advantage. In this talk, different approaches for the construction of spherical wavelets which are themselves radials basis functions or which are based on them are discussed. Obviously, they are naturally candidates for the solution of pseudo differential equations on the sphere. (Received September 06, 2010)

1067-41-512 **Christian Gerhards*** (gerhards@mathematik.uni-kl.de), TU Kaiserslautern, Department of Mathematics, Geomathematics Group, PO Box 30 49, 67653 Kaiserslautern, Germany. *A Spatially Oriented Approach to Geomagnetic Modeling.*

We present some recent applications of multiscale methods to the modeling of Earth's magnetic field. More precisely, we construct regularized convolution kernels for the separation of vector fields with respect to interior and exterior sources, as well as for the reconstruction of tangential current systems. Main ingredient for the kernels are Green's function for the Beltrami operator and the single layer kernel. This offers the possibility of a multiscale decomposition with locally supported wavelets. We mention both a globally reflected approach that requires global information for a first trend approximation and a locally reflected approach where the necessity of global information is substituted by boundary values with respect to the spherical subdomain under consideration. (Received September 07, 2010)

1067-41-816 **Charles Knessl*** (knessl@uic.edu), Department of Math., Stat. and Comp. Sci., 851 South Morgan St., Chicago, IL 60607-7045, and **Sohn Eunju** (esohn@math.uga.edu), Boyd Graduate Research Center, Athens, GA 30606. *Asymptotic Analysis of Dynamic Storage Allocation Models.*

We consider dynamic storage allocation models, which have m primary holding spaces and infinitely many secondary ones. All of the spaces are numbered and ordered. An arriving customer takes the lowest available space. We define the traffic intensity ρ to be λ/μ where λ is the customers' arrival rate and μ is the service rate. We study the joint probability distribution of the numbers of occupied primary and secondary spaces. In the infinite server (IS) model, each stored item is serviced at a rate μ, while in the processor sharing (PS) model each stored item is served at rate μ/N, where N is the total number of stored items present. We analyze these models asymptotically, for $\rho \to 1$ for the PS model, and for $\rho \to \infty$ for the IS model. We also discuss some simpler models that bound the PS model from above or from below. The models correspond to solving certain difference equations, and our analysis involves asymptotic expansions, singular perturbations and special functions. (Received September 15, 2010)

1067-41-949 **Charles Knessl** and **Miao Xu*** (mxu6@uic.edu). *On a free boundary problem for an American put option under the CEV process.*

We consider an American put option under the CEV process. This corresponds to a free boundary problem for a PDE. A nonlinear integral equation that satisfies the free boundary is derived from the PDE. We analyze it in the limit of small $\rho = 2r/\sigma^2$, where r is the interest rate and σ is the volatility. We employ asymptotic and perturbation methods to derive exact and approximate formulas and find that the free boundary behaves differently for five ranges of time to expiry. (Received September 16, 2010)

1067-41-1427 **Salam Md. Mahbubush Khan*** (khan@math.fsu.edu), Department of Mathematics, Alabama A&M University, 4900 Meridian Street, Normal, AL 35762. *Approximation of the Generalized Poisson-Binomial Distribution.*

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 these generalized distributions and their cumulative sums. It is also useful to obtain approximations for the generalized distributions and to know their relationship with other distributions. Here we approximate the generalized Poisson-Binomial distribution by using different techniques and suggested the best approximation. We also derive the standard normal approximation of generalized Poisson-Binomial 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 September 21, 2010)

1067-41-1569 **Vladimir Temlyakov**, Department of Mathematics, University of South Carolina, Columbia, SC 29208, and **Mingrui Yang*** (yangm@email.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Greedy Algorithms in Compressed Sensing.*

One of the important problems in CS is to design an economical algorithm that finds (approximates) u from the information $y = (\langle u, \varphi_1\rangle, \dots, \langle u, \varphi_n\rangle) \in \mathbb{R}^n$. The crucial step here is to build a *sensing* set of vectors $\varphi_j \in \mathbb{R}^m$, $j = 1, \dots, n$ that is *good* for all vectors $u \in \mathbb{R}^m$. Orthogonal Greedy Algorithm (OGA), also called Orthogonal Matching Pursuit (OMP), is one of such well performed algorithms in the noiseless case. However, although OGA is simple and fast, the greedy step is computationally unstable and expensive, especially for large scale problems. This motivated the following modification of OGA: replace the greedy step of OGA by a thresholding step. We call it Orthogonal Greedy Algorithm with Thresholding (OGAT). We prove that, assuming sufficient sparsity of an ideal noiseless signal and some certain coherence property of the overcomplete dictionary, the noiseless signal can be recovered exactly via OGAT. (Received September 22, 2010)

1067-41-1613 **Jameson Cahill**, **Pete Casazza** and **Shidong Li*** (shidong@sfsu.edu), Department of Mathematics, San Francisco State University, San Francisco, CA 94132. *Sparsity of the fusion frame operator and nonorthogonal fusion frames.*

Fusion Frames study ways in which functions or signals from a set of subspaces can be combined coherently regardless how complicated subspaces are related. It has a deep root in data fusion applications for distributed systems such as sensor networks. Nevertheless, it has been seen that the fusion operation involves a fusion frame operator that is seldom sparse. While some applications can enjoy powerful constructions of Parseval fusion frames, a lot more distributed systems do not have the luxury for subspace selections, nor for subspace transformations or rotations. Non-orthogonal fusion frames extend fusion frames in which non-orthogonal projections become fundamental building blocks. We show that not only the (non-orthogonal) fusion frame operator can become sparse, it can also be made diagonal. Multi-fusion frames are also naturally introduced. As a result, the set of underlying subspaces no longer needs to be complete. Tight (non-orthogonal) fusion frames can be built based on one proper subspace. Simple and natural implementation of the non-orthogonal fusion frames via pseudoframes for subspace will be discussed. Comments on related works and why projections are necessary tools will be provided. (Received September 21, 2010)

1067-41-1817 **G Richard Baraniuk*** (richb@rice.edu), MS-380 Dept ECE, 6100 Main Street, Houston, TX 77005. *Recent Progress in Sparse Signal Recovery and Processing.*

Sensors, imaging systems, and communication networks are under increasing pressure to accommodate ever larger and higher-dimensional data sets; ever faster capture, sampling, and processing rates; ever lower power consumption; communication over ever more difficult channels; and radically new sensing modalities. The foundation of today's digital data acquisition systems is the Shannon/Nyquist sampling theorem, which asserts that to avoid losing information when digitizing a signal or image, one must sample at least two times faster than the signal's bandwidth, at the so-called Nyquist rate. Unfortunately, the physical limitations of current sensing systems combined with inherently high Nyquist rates impose a performance brick wall to a large class of important and emerging applications. This talk will overview some of the recent progress on compressive sensing, a new approach to data acquisition in which analog signals are digitized not via uniform sampling but via measurements using more general, even random, test functions. The implications of compressive sensing are promising for many applications and enable the design of new kinds sensors and signal processing systems.
(Received September 21, 2010)

1067-41-1937 **Yuliya Babenko*** (ybabenko@kennesaw.edu), Department of Mathematics and Statistics, Kennesaw State University, 1000 Chastain Road, #1204, Kennesaw, GA 30144, and **Tatyana Leskevich**. *Exact asymptotics of the error of adaptive approximation by harmonic splines.*

Approximation by various types of splines is one of the standard procedure in many applications. In all these applications, there is a standard distinction between uniform and adaptive methods. In the uniform case, the domain of interest is decomposed into a partition where elements do not vary much. Adaptive partitions take into consideration local variations in the function behavior and therefore provide more accurate approximations. However, no polynomial time algorithm exists to provide an optimal approximant for each given function. Therefore, the next natural question would be to construct asymptotically optimal sequences of partitions and approximants on them. In this talk, first we shall briefly present a general scheme for obtaining the asymptotical estimates for the error of interpolation and approximation by splines in various settings (bivariate as well as multivariate). Then we shall introduce our recent results on sharp asymtotics of the interpolation error by polynomial splines on box partitions. However, polynomial splines are not always the optimal choice in multivariate case, and (poly)harmonic splines can be a more natural interpolation tool. We will present the sharp asymptotics of the error of approximation by interpolating harmonic splines. (Received September 22, 2010)

42 ► Fourier analysis

1067-42-112 **William O. Bray*** (bray@math.umaine.edu), Department of Mathematics and Statistics, 333 Neville Hall, University of Maine, Orono, ME 04469. *Partial Abel Transforms on Damek-Ricci spaces and their application.* Preliminary report.

Harmonic analysis and integral geometry on Damek-Ricci spaces, a.k.a. harmonic $NA-$groups, have been extensively studied in the past two decades and is a natural extension of the known theory for rank one symmetric spaces of non-compact type. In this talk we define partial Abel transforms which serve to intertwine the Laplace operator on two Damek-Ricci spaces. As consequence, integral formulas relating the spherical functions on the spaces is determined. Special cases of the latter lie in the work of Ricci (Rend.Sem.Mat.Univ.Pol (1992)) and the work of Bray and Pinsky (Jour.Func.Anal. (1997)). (Received July 24, 2010)

1067-42-263 **Enrico Au-Yeung** and **John J Benedetto*** (jjb@math.umd.edu), Norbert Wiener Center, Department of Mathematics, University of Maryland, College Park, MD 20742. *Balayage and the theory of generalized Fourier frames.* Preliminary report.

Originating in Christoffel's notion of balayage in 1871, and developed in the area of potential theory, we focus on Beurling's theorem, which in modern terminology asserts that balayage gives rise to Fourier frames. We extend this point of view into a new theory in a significant way. In this first part of the extension we construct frames by proving classical theorems depending on measures that go beyond the original Beurling approach. It should be pointed out that the Wiener-Beurling theory of spectral synthesis plays an intrinsic role in this approach. (Received August 14, 2010)

1067-42-341 **Ryan M Berndt*** (rberndt@ottterbein.edu), 1 South Grove Street, Otterbein University, Westerville, OH 43081. *Two weight problem for the Fourier transform.* Preliminary report.

The two weight problem for the Fourier transform consists of finding necessary and/or sufficient conditions on functions u and v such that $\left(\int |f|^q u\right)^{1/q} \leq C\left(\int |f|^p v\right)^{1/p}$ for all $f \in F$. We show that by varying the space of functions F and exploiting the natural dilation and translation invariance of the inequality, we are able to find interesting conditions on u and v that dovetail nicely with the existing literature. (Received August 24, 2010)

1067-42-417 **Alex Iosevich*** (iosevich@math.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627. *On simplexes determined by fractal subsets of the Euclidean space.*

We prove that if the Hasudorff dimension of a subset of the Euclidean space is sufficiently large, then the Lebesgue measure of the set of k-simplexes determined by this set is positive. This is a natural generalization of the Falconer distance problem and is a continuous variant of a class of problems in discrete geometry. Connections with the theory of multi-linear operators and discrete geometry are explored. (Received September 02, 2010)

1067-42-475 **Michael T. Lacey*** (lacey@math.gatech.edu), Mathematics, Atlanta, GA 30332. *The linear bound in A_2 characteristic for Calderon-Zygmund operators.*

In all dimensions, weight w in Muckenhoupt class A_2, and L^2 bounded normalized Calderon-Zygmund operators T, T maps $L^2(w)$ to $L^2(w)$ with norm bounded by the A_2 characteristic of w to the first power. This is

the sharp power on the A_2 characteristic, and represents a culmination of a line of investigation started by Hunt-Muckenhoupt-Wheeden in 1973. We will summarize the efforts of many people to prove this bound. These include a profound extension of the David-Journe $T1$ theorem to the A_2 setting, due to Perez-Treil-Volberg. And different three different approaches to verifying the testing conditions in the $T1$ theorem, which include work of Tuomas Hytonen, Maria Carmen Reguera, Eric Sawyer, Ignacio Uriate-Tuero, and Armen Vagharshakyan, as well as Perez-Treil-Volberg already mentioned. (Received September 06, 2010)

1067-42-494 **Javier Parcet*** (javier.parcet@icmat.es), Instituto de Ciencias Matematicas, Consejo Superior Investigaciones Cientificas, C/ Nicolas Cabrera 13-15, 28049 Madrid, Madrid, Spain. *Schur multipliers of Calderon-Zygmund type.*

Given a discrete group G with left regular representation λ, we explote the trace preserving isomorphism $\mathcal{B}(\ell_2(\mathrm{G})) \simeq \ell_\infty(\mathrm{G}) \rtimes_\lambda \mathrm{G}$ to identify Schur multipliers in $\mathcal{B}(\ell_2(\mathrm{G}))$ with certain noncommutative Calderón-Zygmund operators. Applying recent results, we may provide sufficient conditions on the Schur multiplier to be an $S_\infty(\ell_2(\mathrm{G})) \to \mathrm{BMO}$ bounded map for some natural matrix BMO space. Examples will be provided. Joint work with M. Junge and T. Mei. (Received September 07, 2010)

1067-42-637 **Palle Jorgensen** (jorgen@math.uiowa.edu), **Keri Kornelson*** (kkornelson@math.ou.edu) and **Karen L. Shuman** (shumank@math.grinnell.edu). *Isometries on Bernoulli measures.* Preliminary report.

We study Fourier bases on Hilbert spaces arising from Bernoulli affine iterated function systems on the real line. When the choice of orthonormal basis is not unique, there are naturally arising isometric operators on these spaces. We examine these operators, discovering information about their spectra. (Received September 12, 2010)

1067-42-799 **Steven C Hofmann*** (hofmanns@missouri.edu), Dept. of Mathematics, University of Missouri, Columbia, MO 65211. *Harmonic analysis and uniform rectifiability.*

We discuss joint work with J.-M. Martell, and with Martell and I. Uriarte-Tuero, concerning a rather sharp relationship between higher integrability of the Poisson kernel, and the geometry of a domain. (Received September 14, 2010)

1067-42-1050 **Eric Weber*** (esweber@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011. *Bessel Sequences of Exponentials on Fractal Measures.*

Some fractal measures ν have (orthogonal) spectra–a sequence of exponentials which form an orthonormal basis in $L^2(\nu)$–but many do not. We will discuss a number of results which use a fractional Beurling density to attempt to describe nonorthogonal spectra for a fractal measure μ–sequences of exponentials which form a Bessel sequence or a Riesz basic sequence in $L^2(\mu)$, even if μ does not have an orthogonal spectrum.

The results include collaboration with Dorin Dutkay, Deguang Han, and Qiyu Sun. (Received September 17, 2010)

1067-42-1165 **Judith A. Packer*** (packer@colorado.edu), Department of Mathematics, CB 395, University of Colorado at Boulder, Boulder, CO 80309-0395. *Tensor products of generalized multiresolution analyses.* Preliminary report.

Consider a generalized multiresolution analysis (GMRA) $(\{V_j\},\ \pi, \delta)$ for a discrete abelian group and non-surjective automorphism pair (Γ, α), where $\alpha(\Gamma)$ has finite index in Γ and $\cap_{n=0}^{\infty}(\alpha^n(\Gamma)) = \{0_\Gamma\}$. Here the V_j are nested subspaces of the Hilbert space $\mathcal{H}$ satisfying the standard intersection and density conditions, π is a representation of Γ on $\mathcal{H}$ with invariant subspace V_0, δ is a unitary dilation on $\mathcal{H}$, with $\delta^1 \circ \pi_\gamma \circ \delta = \pi_{\alpha(\gamma)}$. We discuss a recent construction of L. Baggett, V. Furst, K. Merrill, and the author, where we are given a system $(\{V_j'\}, \pi', \delta)$ for a different discrete abelian group/automorphism pair (Γ', α'), where we do not necessarily insist $\cap_{j\in\mathbb{Z}} V_j' = \{\mathbf{0}\}$. We analyze some interesting examples and natural questions that arise when one constructs the Cartesian product $(\Gamma \times \Gamma', \alpha \times \alpha')$ and the corresponding triple $(\{V_j \otimes V_j'\}, \pi \otimes \pi',\ \delta \otimes \delta')$ in $\mathcal{H} \otimes \mathcal{H}'$. (Received September 19, 2010)

1067-42-1200 **Frank Filbir**, **Hrushikesh N. Mhaskar** and **Jürgen Prestin*** (prestin@math.uni-luebeck.de), Institute of Mathematics, University of Lübeck, Wallstr. 40, D-23560 Lübeck, Germany. *On the problem of parameter estimation in exponential sums.*

Given finitely many samples of the sum of exponentials

$$x(k) = \sum_{j=-I}^{I} a_j \exp(-\mathrm{i}\omega_j k) + \epsilon(k), \qquad k = -2N, \cdots, 2N,$$

where $\epsilon(k)$ are random variables with mean zero, each in the range $[-\epsilon, \epsilon]$ for some $\epsilon > 0$, we determine approximately the frequencies ω_j. We combine the features of several recent works to use the available information to construct the moments of a positive measure on the unit circle. In the absence of noise, the support of this measure is exactly $\{\exp(-i\omega_j) : a_j \neq 0\}$. This support can be recovered as the zeros of the monic orthogonal polynomial of an appropriate degree on the unit circle with respect to this measure. In the presence of noise, this orthogonal polynomial structure allows us to provide error bounds in terms of ϵ and N. Together with an appropriate algorithm to construct orthogonal polynomials given the moments, our construction of the moments yields a stable and efficient algorithm to compute the frequencies. (Received September 20, 2010)

1067-42-1298 **Palle E. T. Jorgensen** (jorgen@math.uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242, and **Myung-Sin Song*** (myungsin.song@gmail.com), Department of Mathematics and Statistics, Southern Illinois University Edwardsville, Box 1653, Edwardsville, IL 62026. *Matrix Factorization and Lifting.*

As a result of recent interdisciplinary work in signal processing (audio, still-images, etc), a number of powerful matrix operations have led to advances both in engineering applications and in mathematics. Much of it is motivated by ideas from wavelet algorithms. The applications are convincing measured against other processing tools already available, for example better compression (details below). We develop a versatile theory of factorization for matrix functions. By a matrix valued function we mean a function of one or more complex variables taking values in the group $GL(n, \mathbf{C})$ of invertible $n \times n$ matrices. Starting with this generality, there is a variety of special cases, also of interest, for example, one variable, or restriction to the case $n = 2$; or consideration of subgroups of $GL(n, \mathbf{C})$ or $SL(n, \mathbf{C})$, i.e., specializing to the case of determinant equal to one. A factorization theorem and sketch its application to signal(image processing) in the framework of multiple frequency bands will be shown. (Received September 20, 2010)

1067-42-1309 **Bin Han*** (bhan@math.ualberta.ca), Department of Mathematical and Statistical Sc, University of Alberta, Edmonton, AB T6G 2G1, Canada. *Wavelets and Framelets in Sobolev Spaces.* Preliminary report.

In this talk, we shall present some recent results on wavelets and framelets in function spaces such as Sobolev spaces, which are of particular interest in the wavelet applications in image processing and numerical solutions to differential equations. We shall present some general results on wavelets and framelets in Sobolev spaces which are derived from multivariate refinable functions. Several examples will be given to show that it is very easy to construct multivariate wavelet frames in Sobolev spaces. If time permits, we will also present some theoretical results on frequency-based framelets in the distribution space and directional tight framelets that are of interest in image denoising. Related references are available at http://www.ualberta.ca/ bhan/publ.htm (Received September 20, 2010)

1067-42-1410 **Manos Papadakis*** (mpapadak@math.uh.edu), 651 Phillip G Hoffman Hall, Department of Mathematics, University of Houston, Houston, TX 77204-3008. *Filtering Directional Bias and the Construction of Artifact-free Synthetic Tubular Structures in 3D.* Preliminary report.

Digital filters for 2D or 3D-images are generated as the Fourier transforms of square-integrable $\mathbb{Z}^d$-periodic functions ($d = 2, 3$). These filters are sequences that belong to ℓ^d whose entries are called filter taps, while the $\mathbb{Z}^d$-periodic functions from which the filters are generated are referred to as the *transfer function* of the filter. Transfer functions of filters may tend to produce artifacts in certain directions, depending on the variability of the decay rate of the filter's transfer function. This type of variability, which we call directional bias of the filter, is sometimes desirable, e.g. for filters used for directional representations, but in other occasions it may produce errors in the imaging process. We rigorously study the problem of directional bias and of the associated aliasing errors that occur in image reconstruction due to filtering directional bias. We illustrate our findings by showing the effects of filtering directional bias in the construction of artifact-free synthetic tubular structures in 3D used for validating dendritic arbor centerline detection algorithms applied to 3D-images of neurons. These synthetic data are part of joint work with P.H. Herrera and I.A. Kakadiaris. (Received September 20, 2010)

1067-42-1517 **Kathy D. Merrill*** (kmerrill@ColoradoCollege.edu), Department of Mathematics, Colorado College, 14 E. Cache La Poudre, Colorado Springs, CO 80903. *Simple wavelet sets for multiwavelets in $\mathbb{R}^2$ and $\mathbb{R}^3$.* Preliminary report.

New examples will be presented. (Received September 21, 2010)

1067-42-1598 **Rui Yu*** (yur@email.sc.edu), Department of Mathematics, University of South Carolina, 1523 Greene Street, Columbia, SC 29208, **Vladimir Temlyakov** (Temlyak@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208, and **Dmitriy Bilyk** (bilyk@math.sc.edu), Department of Mathematics, University of South Carolina, 1523 Greene Street, Columbia, SC 29208. *Fibonacci Sets are good for discrepancy and numerical integration.*

We study the Fibonacci sets from the point of view of their quality for numerical integration and discrepancy. Let $\{b_n\}_{n=0}^{\infty}$ be the sequence of Fibonacci numbers. The b_n-point Fibonacci set $\mathcal{F}_n \subset [0,1]^2$ is defined as $\mathcal{F}_n := \{(\mu/b_n, \{\mu b_{n-1}/b_n\})\}_{\mu=1}^{b_n}$, where $\{x\}$ is the fractional part of a number $x \in \mathbb{R}$. It is known that cubature formulas based on Fibonacci sets $\mathcal{F}_n$ give optimal in the sense of order rate of error of numerical integration for classes of functions with mixed smoothness.

We prove that the Fibonacci sets have optimal in the sense of order L_∞ discrepancy. We establish that the symmetrized Fibonacci set $\mathcal{F}_n' := \{(p_1,p_2) \cup (p_1, 1-p_2) : (p_1,p_2) \in \mathcal{F}_n\}$ has minimal in the sense of order L_2 discrepancy and provide an exact formula for this quantity. We also introduce centered L_p discrepancy which is a modification of the L_p discrepancy to make it symmetric with respect to the center of the unit square. We prove that the Fibonacci set $\mathcal{F}_n'$ has minimal in the sense of order centered L_p discrepancy for all $p \in (1,\infty)$. We apply the Fourier method to prove the results. (Received September 21, 2010)

1067-42-1668 **Maria Carmen Reguera*** (mreguera@math.gatech.edu). *On Muckenhoupt-Wheeden Conjecture.*

We present a result on a conjecture by B. Muckenhoupt and R. Wheeden, a weak-type estimate in weighted theory. It is a natural extension of a classical inequality proved by C. Fefferman and E. Stein in early seventies and has been an open problem since then. Let w be a weigth, M denote the Maximal Function and T a Calderón-Zygmund operator, the estimate we are referring to is

$$\sup_{t>0} tw\,\{x \in \mathbb{R} \mid |Tf(x)| > t\} \leq C \int_{\mathbb{R}} |f| Mw(x) dx.$$

We show that there is a weight w, and Haar multiplier T for which the above inequality fails when M is replaced by the Dyadic Maximal Function. This shows that a dyadic version of Muckenhoupt-Wheeden Conjecture is false. This accomplished by using current techniques in weighted inequalities to show that a particular L^2 consequence of the inequality above does not hold. (Received September 21, 2010)

1067-42-1759 **Dmitriy Bilyk**, **Xiaomin Ma** and **Jill Pipher*** (jpipher@math.brown.edu), Box 1917, Department of Mathematics, Brown University, Providence, RI 02912, and **Craig Spencer**. *Geometric discrepancy and lattice constructions.*

We present some results in discrepancy theory in two dimensions in which certain rotations of the standard lattice are shown to have low discrepancy with respect to families of (rotated) rectangles. (Received September 21, 2010)

1067-42-2102 **David V. Cruz-Uribe*** (david.cruzuribe@trincoll.edu), Department of Mathematics, Trinity College, 300 Summit St., Hartford, CT 06106, and **José María Martell** and **Carlos Pérez**. *Sharp weighted norm inequalities for classical operators.*

Over the past decade there has been great interest in finding the sharp constant (in terms of the A_p constant) for weighted norm inequalities for singular integrals. I will describe joint work C. Pérez and J.M. Martell where we gave an elementary proof of the sharp constant for singular integrals that can be approximated by dyadic Haar shift operators. (These include the Hilbert transform, Riesz transforms, and the Beurling-Ahlfors operator.) Our approach also yields sharp one-weight results for commutators of these singular integrals and other operators such as the dyadic square function and the vector-valued maximal operator, and also sharp two-weight results. (Received September 22, 2010)

1067-42-2276 **Eyvindur Ari Palsson*** (eap48@cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853-4201. *L^p estimates for a singular integral operator motivated by Calderón's second commutator.*

When Calderón studied his commutators, in connection with the Cauchy integral on Lipschitz curves, he ran into the bilinear Hilbert transform by dropping an average in his first commutator. He posed the question whether this new operator satisfied any L^p estimates. Lacey and Thiele showed a wide range of L^p estimates in two papers from 1997 and 1999. By dropping two averages in the second Calderón commutator one bumps into the trilinear Hilbert transform. Finding L^p estimates for this operator is still an open question.

In my talk I will discuss L^p estimates for a singular integral operator motivated by Calderón's second commutator by dropping one average instead of two. I will motivate this operator from a historical perspective and give some comments on how it might be useful in partial differential equations. (Received September 22, 2010)

1067-42-2307 **Sanjiv Kumar Gupta*** (gupta_s_63@yahoo.com), PO BOX-36, Al-Khodh, 123 , Oman. *Dichotomy Conjecture on Compact Symmetric Spaces.*

We prove that for any classical, compact, simple, connected Lie group G, the G-invariant orbital measures supported on non-trivial conjugacy classes satisfy a **surprising L^2-singular dichotomy**: For any natural number k, either $\mu_h^k \in L^2(G)$ or μ_h^k is singular to the Haar measure on G. The minimum exponent k for which $\mu_h^k \in L^2$ is specified; it depends on Lie properties of the element $h \in G$. As a corollary, we complete the solution to a classical problem-to determine the minimum exponent k such that $\mu^k \in L^1(G)$ for all central, continuous measures μ on G. Generalisation of this **L^2-singular dichotomy** to compact symmetric spaces will also be discussed. This is joint work with Prof. K. Hare at the University of Waterloo, Canada. (Received September 22, 2010)

1067-42-2324 **Matthew R Bond*** (bondmatt@msu.edu), 500 W Lake Lansing Rd D26, East Lansing, MI 48823, and **A Volberg**. *Buffon's needle landing near Besicovitch irregular self-similar sets.*

Consider L closed disjoint discs of radius $1/L$ inside the unit disc. By using linear maps of smaller disc onto the unit disc we can generate a self-similar Cantor set G. Then $\mathcal{G} = \bigcap_n \mathcal{G}_n$. One may then ask the rate at which the Favard length – the average over all directions of the length of the orthogonal projection onto a line in that direction – of these sets $\mathcal{G}_n$ decays to zero as a function of n. In the paper of Nazarov–Peres–Volberg, it was shown that for 1/4 corner Cantor set one has $p < 1/6$, such that $Fav(\mathcal{K}_n) \leq \frac{c_p}{n^p}$, and in Laba–Zhai and Bond–Volberg the same type power estimate was proved for the product Cantor sets (with an extra tiling property) and for the Sierpinski gasket S_n for some other $p > 0$. In the present work we give an estimate that works for *any* Besicovitch set which is self-similar. However the estimate is worse than the power one. The power estimate appears to be related to a certain regularity property of zeros of a corresponding self-similar sum of exponential functions. (Received September 22, 2010)

1067-42-2426 **Li-An Daniel Wang*** (lwang3@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *Multiplier theorem on anisotropic Hardy spaces.*

The anisotropic Hardy space H_A^p, for $p \in (0, 1]$, is a generalization of the classical Hardy space in which the Euclidean norm is replaced by a quasinorm associated with a dilation matrix A. We answer the following question: Under what conditions on a multiplier m will the operator $Tf = (\hat{f}m)^\vee)$ be bounded on H_A^p? (Received September 23, 2010)

43 ► Abstract harmonic analysis

1067-43-271 **Maria Carmen Reguera*** (mreguera@math.gatech.edu). *A counterexample related to Muckenhoupt-Wheeden conjecture.*

The following conjecture about weak L^1 weighted estimates was posed by B. Muckenhoupt and R. Wheeden in the early 70's. If w is a weight, i.e. w is locally integrable and non-negative function, M is the Hardy-Littlewood Maximal operator and T is a Calderón-Zygmund operator then

$$\sup_{t>0} tw\{x \in \mathbb{R} \mid |Tf(x)| > t\} \leq C \int_{\mathbb{R}} |f| Mw(x) dx.$$

With a positive answer to the conjecture when M is replaced by $M_{L(logL)^\epsilon}$ due to C. Pérez, very little has been known about this difficult problem. In this talk we provide a negative answer to the dyadic version of the above conjecture, i.e. replacing M by the dyadic maximal function we can find a weight w and a Haar multiplier T such that the inequality above is false. (Received August 15, 2010)

1067-43-556 **Jens Gerlach Christensen*** (jens@math.umd.edu). *Sampling in reproducing kernel Banach spaces on Lie groups.*

We derive sufficient conditions on the reproducing kernel Banach space and its reproducing kernel to ensure that it is possible to reconstruct a function from its samples. This has applications in wavelet theory and in particular for deriving atomic decompositions and frames for coorbit spaces. In particular we show how to use Gårding vectors as atoms. (Received September 09, 2010)

1067-43-715 **Junxia Li*** (jxl004@uark.edu), Faytteville, AR 72701, **John Ryan**, Fayetteville, AR 72701, and **Peter Van Lanker**. *Some Rarita-Schwinger type operators.*

The Rarita-Schwinger operators R_k arise in representation theory of Pin and Spin groups. When $k = 0$ it is the Dirac operator. At the beginning of this work we will study the Rarita-Schwinger operators and construct their fundamental solutions. Next, we will discuss some basic integral formulas related to these operators. We also present Rarita-Schwinger type Laplacians together with their fundamental solutions and Green's formula. The conformal invariance of the first and the second order operators is also established here. This is a joint work with John Ryan and Peter Van Lanker. (Received September 13, 2010)

1067-43-745 **Nico Spronk*** (nspronk@uwaterloo.ca), 200 University Ave. W., Waterloo, Ontario N2L3G1, Canada. *Beurling-Fourier algebras of compact groups.*

Let G be a compact group. I will introduce a class of p-Beurling-Fourier algebras $A^p_\omega(G)$ where $1 \leq p \leq \infty$, and $\omega : \widehat{G} \to \mathbb{R}^{>0}$ is a weight function. If $p = 1$ and $\omega = 1$ is the constant weight, then this algebra is the classical Fourier algebra$A(G)$. If G is abelian then for any p, $A^p_\omega(G) = \ell^1(\widehat{G}, \omega)$ is a classical Beurling algebra.

I will survey a some results on these algebras. J. Ludwig, L. Turowska and I have obtained results on the Gelfand spectrum, as well as results on regularity and sets of spectral synthesis. H.H. Lee,E. Samei and I have obtained results on when $A^p_\omega(G)$ is an operator algebra. I will discuss future directions for these ideas. (Received September 14, 2010)

1067-43-813 **Gail Ratcliff*** (ratcliffg@ecu.edu) and **Chal Benson** (bensonf@ecu.edu). *Geometric models for the spectra of certain Gelfand pairs associated with Heisenberg groups.*

Let K be a compact Lie group acting on a finite dimensional Hermitian vector space V via some unitary representation. Then K acts by automorphisms on the associated Heisenberg group $H_V = V \times \mathbb{R}$ and we say that (K, H_V) is a Gelfand pair when the algebra $L^1_K(H_V)$ of integrable K-invariant functions on H_V commutes under convolution. In this situation an application of the Orbit Method yields an injective mapping Ψ from the space $\Delta(K, H_V)$ of bounded K-spherical functions on H_V to the space $\mathfrak{h}^*_V/K$ of K-orbits in the dual of the Lie algebra of H_V. We show that Ψ is a homeomorphism onto its image provided that the action of K on V is "well-behaved" in a sense made precise in this work. Our result encompasses a widely studied class of examples arising in connection with Hermitian symmetric spaces. (Received September 15, 2010)

1067-43-1133 **Fulton B Gonzalez*** (fulton.gonzalez@tufts.edu), Department of Mathematics, Tufts University, Medford, MA 02155. *Conical Distributions on the Space of Flat Horocycles.*

Let $G_0 = K \ltimes \mathfrak{p}$ be the Cartan motion group associated with a noncompact semisimple Riemannian symmetric pair (G, K). Let $\mathfrak{a}$ be a maximal abelian subspace of $\mathfrak{p}$ and let $\mathfrak{p} = \mathfrak{a} + \mathfrak{q}$ be the corresponding orthogonal decomposition. A flat horocycle in $\mathfrak{p}$ is a G_0-translate of $\mathfrak{q}$. A conical distribution on the space Ξ_0 of flat horocycles is an eigendistribution of the algebra $\mathbb{D}(\Xi_0)$ of G_0-invariant differential operators on Ξ_0 which is invariant under the left action of the isotropy subgroup of G_0 fixing $\mathfrak{q}$. In this talk, we show that the space of conical distributions belonging to each generic eigenspace of $\mathbb{D}(\Xi_0)$ is one-dimensional, and we classify the set of all conical distributions on Ξ_0 when G/K has rank one. We also consider relations with the flat horocycle Radon transform and the question of the irreducibility of the natural representation of G_0 on the eigenspaces of $\mathbb{D}(\Xi_0)$. (Received September 19, 2010)

1067-43-1134 **Norbert N Youmbi*** (nyoumbi@francis.edu), 117 Evergreen Dr, Sullivan 114, Loretto, PA 15940. *Completely Simple Topological Semihypergroups.*

A semihypergroup S is roughly speaking a topological space that has enough structure so that a convolution could be defined on its vector space of Radon measures M(S). In contrast to topological semigroups, an algebraic operation is not defined on S, rather the convolution of measures is used to defined the possible algebraic concepts on S. We are then logically faced with the question: how much algebraic structure could be inherited from the algebra of measure of a topological semihypergroup? We address this question by proving results, essential in doing harmonic analysis and Probability on semihypergroups. In particular we define a Rees convolution product and show that it actually defines a completely simple semihypergroup. We also give examples to illustrate contrasts between semigroups and semihypergroups. (Received September 19, 2010)

1067-43-1253 **Emily J. King*** (eking@math.umd.edu), 9 Memorial Dr., Room 1N124, Bethesda, MD 20892-0924, and **Maria A. Skopina** (skopina@ms1167.spb.edu). *p-Adic Wavelets: Quincunx MRA and Biorthogonal Systems.*

With an eye toward applications in quantum mechanics and other areas of science, much work has been done to generalize traditional analytic methods to p-adic systems. In 2002 the first paper on p-adic wavelets was published. Since then p-adic wavelet sets, multiresolution analyses, and wavelet frames have all been introduced.

However, so far all constructions have involved dilations by p. This talk presents the first construction of a p-adic wavelet system with a more general matrix dilation (quincunx), as well as some recent characterizations of this type of system. Work being done to completely characterize biorthogonal p-adic systems associated with a multiresolution analyis will also be presented. (Received September 20, 2010)

1067-43-2240 **Nicholas Boros*** (borosnic@msu.edu), 354 Lamb Street, Perry, MI 48872. *Sharp L^p-bounds for a perturbation of Burkholder's Martingale Transform.*

In this talk we discuss how to find the Bellman function associated with proving the following estimate. For $1 < p < \infty, \tau \in [-\frac{1}{2}, \frac{1}{2}], \varepsilon_k \in \{\pm 1\}, n \in \mathbb{Z}_+, \{d_k\}_k$ a martingale difference sequence and $\begin{pmatrix} \varepsilon_k \\ \tau \end{pmatrix}$ a vector in $\mathbb{R}^2$, we obtain

$$\left\| \sum_{k=1}^{n} \begin{pmatrix} \varepsilon_k \\ \tau \end{pmatrix} d_k \right\|_{L^p([0,1),\mathbb{C}^2)} \leq C_{p,\tau} \left\| \sum_{k=1}^{n} d_k \right\|_{L^p([0,1),\mathbb{C})},$$

with $C_{p,\tau}$ as the sharp constant. This is a generalization of Burkholder's famous result, which holds when $\tau = 0$ with $C_{p,\tau} = \max\{p-1, \frac{1}{p-1}\}$, that can similarly be used to obtain sharp estimates of singular integrals. We discuss an application to a singular integral which has an operator norm of $C_{p,\tau}$. This is a joint work with P. Janakiraman and A. Volberg. (Received September 22, 2010)

44 ► Integral transforms, operational calculus

1067-44-192 **Sigurdur Helgason*** (helgason@mit.edu), MA. *A support theorem for the horocycle transform on a hyperbolic space.*

On a noncompact symmetric space S there are two natural Radon transforms, the X ray transform and the horocycle transform. Both have support theorems relative to a fixed ball in S. If S has rank one the interior of a horocycle H is well defined. If H is a fixed horocycle (with S of rank one) the support theorem holds for the X-ray transform relative to H. If S is hyperbolic space we prove a similar support theorem for the horocycls transform relative to H. (Received July 29, 2010)

1067-44-340 **William E Gryc*** (wgryc@muhlenberg.edu), Dept. of Mathematics and Computer Science, Muhlenberg College, 2400 Chew St., Allentown, PA 18104-5586, and **Todd Kemp** (tkemp@math.ucsd.edu), Department of Mathematics, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0112. *The L^p norm of the Segal-Bargmann Transform.*

The Segal-Bargmann projection is a projection $P_\alpha : L^2(\mu_\alpha) \to \mathcal{H}L^2(\mu_\alpha)$, where α is any positive real number, μ_α is a Gaussian measure on $\mathbb{C}^n$ given by $d\mu_\alpha = \left(\frac{\alpha}{\pi}\right)^n e^{-\alpha|z|^2} dm$ (where dm is Lebesgue measure on $\mathbb{C}^n$), and $\mathcal{H}L^2(\mu_\alpha)$ is the space of functions in $L^2(\mu_\alpha)$ that are also holomorphic on $\mathbb{C}^n$. For $1 < p < \infty$, this projection can be extended to a bounded transformation $P_\alpha : L^p(\mu_{\alpha p/2}) \to \mathcal{H}L^p(\mu_{\alpha p/2})$. In fact, if we denote the norm of the above operator as $\|P_\alpha\|_{p\to p}$, it is not difficult to show that $\|P_\alpha\|_{p\to p} \leq 2^n$.

In this talk we will show that in the case $n = 1$, the norm $\|P_\alpha\|_{p\to p}$ can be computed exactly as $\|P_\alpha\|_{p\to p} = \frac{2}{p^{1/p} p'^{1/p'}}$, where p' is defined as $\frac{1}{p'} = 1 - \frac{1}{p}$. For $n > 1$, we will show that $\|P_\alpha\|_{p\to p} \geq \left(\frac{2}{p^{1/p} p'^{1/p'}}\right)^n$. (Received August 24, 2010)

1067-44-432 **Raluca Felea*** (rxfsma@rit.edu), Rochester Institute of Technology, Rochester, NY , and **Todd Quinto** (Todd.Quinto@tufts.edu), Tufts University, Medford, MA. *Microlocal properties for the slant-hole SPECT operator.*

We analyze the model operator in the slant-hole SPECT (Single Photon Emission Computed Tomography) problems which is a particular case of a Fourier integral operator with fold/ blowdown singularities. To reconstruct an image one uses the backprojection operator which in general adds singularities. Using microlocal results, we construct a differential operator which makes the added singularities less strong than the singularities we want to image. (Received September 02, 2010)

1067-44-534 **Leonid A Kunyansky*** (leonk@math.arizona.edu), Department of Mathematics, University of Arizona, 617 N Santa Rita Ave., Tucson, AZ 85721. *Reconstruction of a function from its spherical (circular) means with the centers lying on the surface of certain polygons and polyhedra.*

We present explicit filtration/backprojection-type formulae for the inversion of the spherical (circular) mean transform with the centers lying on the boundary of some polyhedra (or polygons, in 2D). The formulae are derived using the double layer potentials for the wave equation, for the domains with certain symmetries. The formulae are valid for a rectangle and certain triangles in 2D, and for a cuboid, certain right prisms and a certain pyramid in 3D. All the present inversion formulae yield exact reconstruction within the domain surrounded by the acquisition surface even in the presence of exterior sources. (Received September 08, 2010)

1067-44-929 **Alexander Katsevich*** (akatsevi@mail.ucf.edu), Mathematics Dept, University of Central Florida, Orlando, FL 32816. *Singular value decomposition for the truncated Hilbert transform.*

Starting from a breakthrough result by Gelfand and Graev, inversion of the Hilbert transform became a very important tool for image reconstruction in tomography. In particular, their result is useful when the tomographic data are truncated and one deals with an interior problem. As was established recently, interior problem admits a stable and unique solution when some *a priori* information about the object being scanned is available. The most common approach to solving the interior problem is based on converting it to the Hilbert transform and performing analytic continuation. Depending on what type of tomographic data are available, one gets different Hilbert inversion problems. In this talk we consider two such problems and establish singular value decomposition for the operators involved. We also propose algorithms for performing analytic continuation. (Received September 16, 2010)

1067-44-2252 **Claudiu Mihai*** (cmihai@daemen.edu), Daemen College, 4380 Main St, Amherst, NY 14226. *Asymptotic Laplace Transforms and Watson's Lemma .*

The purpose of this talk is to present an asymptotic version of the Laplace transform which have the benefit that all $f \in L^1_{loc}([0,\infty);X)$ are transformable. The usefulness of the Laplace transform in applications to differential and integral equations is due to the fact that it maps differentiation, integration, and more generally, convolution onto multiplication.We will show that these crucial operational properties extend to the Asymptotic Laplace Transform as well. Finally, we will show that for every locally integrable function that admits an asymptotic expansion in terms of t^n, its associated Laplace Transform admits an asymptotic expansion in terms of $\frac{1}{\lambda^n}$. (Received September 22, 2010)

45 ► Integral equations

1067-45-274 **Margo S. Levine*** (margo@pet.mgh.harvard.edu), **Emil Y. Sidky** and **Xiaochuan Pan**. *Consistency Conditions for Cone-Beam CT Data Acquired with a Linear Source Trajectory.*

A consistency condition is developed for computed tomography (CT) projection data acquired from a linear X-ray source trajectory. The condition states that integrals of normalized projection data along detector lines parallel to the X-ray path must be equal. The projection data is required to be untruncated only along the detector lines parallel to the X-ray path, a less restrictive requirement compared to Fourier conditions that necessitate completely untruncated data. The condition is implemented numerically on simple image functions, a discretization error bound is estimated, and detection of motion inconsistencies is demonstrated. The results show that the consistency condition may be used to quantitatively compare the quality of projection data sets obtained from different scans of the same image object. (Received August 15, 2010)

1067-45-743 **Markus Haltmeier*** (markus.haltmeier@unvie.ac.at), Nordbergstrasse 15, 1090 Wien, Austria, 1170 Vienna, Austria. *Determination of a function from integrals over spheres of fixed radius.*

We study the problem of reconstructing a function from integrals over spheres of fixed radius. We discuss applications this problem in photoacoustic imaging with circular integrating detectors, and in photoacoustic imaging using a phase contrast imaging method. (Received September 14, 2010)

1067-45-996 **P. P.B. Eggermont*** (eggermon@udel.edu), Food and Resource Economics, 224 Townsend Hall - 531 South College Avenue, University of Delaware, Newark, DE 19717-1303, and **V. N. LaRiccia** and **M. Z. Nashed**. *Moment discretization of ill-posed problems with discrete weakly bounded noise.* Preliminary report.

We study ill-posed operator equations with weakly bounded noise. The objective is to obtain error bounds on the approximate solution when the weakly bounded noise becomes "small", i.e., when it converges weakly to zero. In the setting of moment discretization, we must deal with a discrete version of weakly bounded noise. This is defined using quadratic forms in the noise involving a positive definite kernel, chosen in accordance with the operator equation under discussion. This naturally leads to reproducing kernel Hilbert spaces, which is of course is the proper setting for moment discretization problems. We derive optimal convergence rates for Tikhonov regularization. Possible extensions to regularization by conjugate gradient methods are explored. (Received September 17, 2010)

1067-45-1775 **Cara D. Brooks*** (brooksca@math.msu.edu) and **Patricia K. Lamm**. *Generalized local regularization of linear inverse problems, with application to Volterra problems in L^p-spaces.* Preliminary report.

A regularization method is formulated which generalizes local regularization for solving linear inverse ill-posed problems. The generalized method, which includes Tikhonov regularization and Lavrentiev regularization as special cases, provides a framework for the design of non-global regularization methods and methods which make use only of the data most relevant to the desired solution.

As an example, a version of local regularization is shown to naturally satisfy the conditions set forth in the generalized method when applied to a class of linear Volterra convolution equations. Convergence of the method is shown for the underlying data spaces $L^p(0,1),\ 1 < p < \infty$. Under assumptions of increased regularity of the true solution, rates of convergence are established for data in $L^p(0,1),\ 1 \le p \le \infty$. (Received September 23, 2010)

1067-45-1868 **Can Huang*** (canhuang2007@gmail.com), 4500 Cass Ave. Apt 1008, Detroit, MI 48201, and **Zhimin Zhang** (ag7761@wayne.edu), 656, West Kirby, Faculaty Administration, Building 1131, Detroit, MI 48202. *Geometric and supergeometric convergence of spectral collocationd method for Volterra or Fredholm integral equations with akly singular kernels.*

A spectral collocation method is used to solve Volterra or Fredholm equations with weakly singular kernels and corresponding integral-differential equations by virtue of some identities. For a class of functions that satisfy a regularity condition (R): $\|y^{(k)}\|_{L^\infty[0,T]} \le ck!R^{-k}$ (condition (M): $\|y^{(k)}\|_{L^\infty[0,T]} \le cM^k$) on a bounded domain, we obtain a geometric (supergeometric) convergence rate in the L_∞ norm as well as a weighted L^2 norm for both types of equations. Numerical results confirm our theoretical analysis. (Received September 22, 2010)

1067-45-1953 **Dashun Xu*** (dxu@math.siu.edu), 1245 Lincoln Drive, Carbondale, IL 62901, and **Gregory J Sandland**, **Dennis J Minchella** and **Zhilan Feng**. *Interactions among virulence, coinfection and drug resistance in a complex life-cycle parasite.*

Motivated by recent empirical studies on Schistosoma mansoni, we use a mathematical model, which consists of ordinary differential and integral equations, to investigate the impact of drug treatment of human hosts and co-infection of intermediate snail hosts by multiple strains of parasites on the evolution of parasites. By examining the evolutionarily stable strategies(ESS) of parasites, our study suggests that higher levels of drug treatments (which usually tend to promote monomorphism as the evolutionary endpoint) will favor parasite strains that have a higher level of drug resistance and a lower level of virulence. Our study also shows that while co-infection of the intermediate host does not affect the levels of drug resistance or virulence of parasites at ESS points, it tends to destabilize ESS points and hence promote dimorphism or even polymorphism as the evolutionary endpoint. (Received September 22, 2010)

1067-45-2345 **Haewon Lee*** (hlee@dillard.edu), Department of STEM (Mathematics Program), College of Arts and Sciences, 2601 Gentilly Blvd., New Orleans, LA 70122, and **Peter Frempong-Mireku** (pfmireku@dillard.edu), Department of STEM (Mathematics Program), College of Arts and Sciences, 2601 Gentilly Blvd., New Orleans, LA 70122. *On Solutions for Fractional-order Functional Integrodifferential Equations with Infinite Delay.* Preliminary report.

In this paper we study the existence of mild solutions for fractional-order functional integrodifferential equations with infinite delay. The results are obtained by using fractional calculus, semigroup theory and the fixed point theorem. (Received September 22, 2010)

1067-45-2369 **Sapto Indratno*** (sapto@math.ksu.edu), 1600 Hillcrest Dr#26, Manhattan, KS 66502, and **Alexander G Ramm**. *Dynamical Systems Method for Solving Ill-conditioned Linear Algebraic Systems.* Preliminary report.

A new method, the Dynamical Systems Method (DSM), justified recently, is applied to solving ill-conditioned linear algebraic system (ICLAS). The DSM gives a new approach to solving a wide class of ill-posed problems. In this paper a new iterative scheme for solving ICLAS is proposed. This iterative scheme is based on the DSM solution. An a posteriori stopping rules for the proposed method is justified. (Received September 22, 2010)

46 ► Functional analysis

1067-46-202 **Ioana Ghenciu*** (ioana.ghenciu@uwrf.edu), River Falls, WI 54022, and **Paul Lewis**. *Unconditional convergence in the strong operator topology and ℓ_∞.* Preliminary report.

In this paper we study non-complemented spaces of operators and the embeddability of ℓ_∞ in the spaces of operators $L(X,Y)$, $K(X,Y)$, and $K_{w^*}(X^*,Y)$. Results of Kalton, Feder, Emmanuele, and Bator and Lewis are generalized. A vector measure result is used to study the complementation of the spaces $W(X,Y)$ and $K(X,Y)$ in the space $L(X,Y)$, as well as the complementation of $K(X,Y)$ in $W(X,Y)$.

A fundamental result of Drewnowski is used to establish a result for operator valued measures, from which we obtain as corollaries the Vitali-Hahn-Saks-Nikodym theorem, the Nikodym Boundedness theorem, and a Banach space version of the Phillips Lemma. (Received August 02, 2010)

1067-46-281 **Sonia Sharma*** (sonia@math.uh.edu), Department of Mathematics, 651 PGH, 4800 Calhoun Rd., University of Houston, Houston, TX 77204. *Real one-sided M-ideals.* Preliminary report.

I will speak briefly about real operator spaces and their complexification. We will look at various results in one-sided M-ideal theory which generalize to spaces over real numbers, and how complexification trick can help in proving some of the results. We will also look at real operator spaces which are a real one-sided M-ideal in their second dual. (Received August 16, 2010)

1067-46-353 **Alexander A. Katz*** (katza@stjohns.edu), St. John's University, Department of Mathematics & Computer Science, 300 Howard Ave., Dasilva Academic Center 314, Staten Island, NY 10301. *On non-associative L_p-spaces associated with Maharam traces on JBW-algebras.*

In our previous paper we considered traces on JBW-algebras (without type I_2-summands) with values in real complete vector lattices. A full description of these traces was obtained in the case of Maharam traces and a Radon-Nikodym type theorem for Maharam traces was established. In the present paper we introduce a class of Banach-Kantorovich spaces which are non-associative L_p-spaces associated with Maharam traces on JBW-algebras without a type I_2-summands. (Received August 26, 2010)

1067-46-478 **Jeremy J Becnel*** (becneljj@sfasu.edu), Department of Mathematics and Statistics, Stephen F. Austin State University, Nacogodches, TX 75962-3040, and **Ambar N Sengupta**, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *A Support Theorem for a Gaussian Radon Transform in Infinite Dimensions.*

We show that in infinite dimensions, if a bounded, suitably continuous, function has zero Gaussian integral over all hyperplanes outside a closed bounded convex set then the function is zero outside this set. This is an infinite-dimensional form of the well-known Helgason Support Theorem for Radon transforms in finite dimensions. (Received September 06, 2010)

1067-46-518 **Michelle R Craddock*** (michelle.craddock@usma.edu), 646 Swift Road, Department of Mathematical Sciences, Thayer Hall 253, West Point, NY 10996. *Reflexivity and Grothendieck Space Property for Positive 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, $\ell_p \tilde{\otimes}_i X$), the Fremlin projective (respectively, the Wittstock injective) tensor product of ℓ_p and X, has reflexivity or the Grothendieck space property if and only if X has the same property and each positive operator from ℓ_p (respectively, from ℓ_q) to X^* (respectively, to X^{**}) is compact. (Received September 08, 2010)

1067-46-560 **Christopher Jankowski*** (cjankows@math.bgu.ac.il), Ben-Gurion University of the Negev, P.O. Box 653, 84105 Be'er Sheva, Israel. *A family of non-cocycle conjugate E_0-semigroups obtained from boundary weight doubles.*

An E_0-semigroup $\alpha = \{\alpha_t\}_{t \geq 0}$ is a semigroup of unital $*$-endomorphisms of $B(H)$ which is weakly continuous in t. Previous work has shown how to induce E_0-semigroups of type II_0 using boundary weight doubles (ϕ, ν), where $\phi : M_n(\mathbb{C}) \to M_n(\mathbb{C})$ is a unital q-positive map and ν is a type II Powers weight. We present cocycle conjugacy results for E_0-semigroups induced by (ϕ, ν) and (ψ, η) in the case that $\phi : M_n(\mathbb{C}) \to M_n(\mathbb{C})$ and $\psi : M_{n'}(\mathbb{C}) \to M_{n'}(\mathbb{C})$ both have rank one. In particular, we find that if ν is a type II Powers weight of the form $\nu(\sqrt{I - \Lambda(1)} A \sqrt{I - \Lambda(1)}) = (f, Af)$, then (ϕ, ν) and (ψ, ν) induce cocycle conjugate E_0-semigroups if and only if $n = n'$ and ϕ is conjugate to ψ. (Received September 09, 2010)

1067-46-602 **Daniel E. L. Redelmeier*** (danielr@math.tamu.edu), 1700 George Bush Dr 207, College Station, TX 77840, and **Ken Dykema**. *A Lower Bound for the Spectral Radius of Random Walks on the Baumslag-Solitar Group.*

The spectral radius of random walks on the Caley graph of groups describe the asymptotics of the return probability of the group. Here we investigate the spectral radius of the Baumslag-Solitar group, a group known for its use in counterexamples. In order to do this we note that the Baumslag-Solitar Group is an HNN extension of the integers. This allows us to use the C* HNN extension of Ueda to write its C*-algebra in terms of an amalgamated free product, and from there to use free probability techniques. With that we find a coefficient lower bound for the moment generating series. Using numerical methods we use this to find a lower bound for the spectral radius of the random walk. (Received September 10, 2010)

1067-46-610 **Yoann N. Dabrowski*** (yoann@math.ucla.edu). *A non-commutative Path Space approach to stationary free Stochastic Differential Equations.*

By defining tracial states on a non-commutative analog of a path space, we construct Markov dilations of certain conservative completely Markov semigroups on finite von Neumann algebras, including all symmetric semigroups. For well chosen semigroups, for instance with generator any divergence form operator associated to a derivation valued in the coarse correspondence, those dilations give rise to stationary solutions of certain free SDEs previously considered by D. Shlyakhtenko.

We also briefly explain two applications : a non-commutative Talagrand's inequality for non-microstate free entropy and the combination of our dilation results with techniques of Popa-Ozawa and Peterson giving the proof that the von Neumann algebra of any finitely generated group with complete metric approximation property and positive first L^2 betti number has no Cartan subalgebras. (Received September 10, 2010)

1067-46-622 **Douglas M Pickrell*** (pickrell@math.arizona.edu), Mathematics Department, University of Arizona, Tucson, AZ 85721. *Heat kernel measures and critical limits.*

In the survey paper ArXiv 0711.0410, I attempted to outline some possible connections between conjectural limits of heat kernel measures on infinite dimensional Lie groups (such as loop groups), and "Feynman-Kac measures" for 2D sigma models with simply connected compact Lie group target. In this brief talk I will attempt to give an overview of this in terms of a single picture. (Received September 11, 2010)

1067-46-701 **David Penneys*** (dpenneys@math.berkeley.edu), 1049 Evans Hall, Berkeley, CA 94720. *Eliminating vines and weeds in the classification of subfactors to index 5.*

In a series of papers by Vaughan Jones, Scott Morrison, the speaker, Emily Peters, Noah Snyder, and James Tener, we implement obstructions to principal graphs in the classification of subfactors up to index 5. In part 2 (arXiv:1007.2240), we eliminate two problematic weeds via a quadratic tangles test developed by Jones (arXiv:1007.1158), and in part 4 (in preparation), we eliminate vines via a theorem about cyclotomicity of graph norms by Frank Calegari, Morrison, and Snyder (arXiv:1004.0665). (Received September 13, 2010)

1067-46-736 **Martin Grothaus*** (grothaus@mathematik.uni-kl.de), P.O. Box 3049, 67653 Kaiserslautern, Germany. *Bargmann–Segal space, generalized functions and Feynman–Kac formula.* Preliminary report.

We give an improved characterization of a space of regular generalized functions in white noise via the Bargmann–Segal space. This enables use to derive a Wick formula for the product of regular generalized functions with Donsker's delta. As an application we construct Feynman–Kac integrands for localized initial conditions and improve a result of Halim Doss on the construction of solutions to the Schrödinger equation. (Received September 14, 2010)

1067-46-785 **Zhe Dong** (dongzhe@zju.edu.cn), Department of Mathematics, Zhejiang University, Hangzhou, Zhejiang 310027, Peoples Rep of China, and **Zhong-Jin Ruan*** (ruan@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *A Hilbert module approach to certain group properties.*

In this talk, we show that there is a natural Hilbert module approach to the exactness and the coarse embedding properties of discrete groups. (Received September 14, 2010)

1067-46-927 **J. Owen Sizemore*** (sizemore@math.ucla.edu). *Rigidity Results for Ergodic Actions of Wreath Product Groups.*

We will discuss von Neumann algebra techniques for classification of ergodic actions of countable groups. We will apply these techniques to get rigidity results for actions of wreath product groups. (Received September 16, 2010)

1067-46-932 **Thomas Sinclair*** (thomas.sinclair@vanderbilt.edu), 1326 Stevenson Ctr, Vanderbilt University, Nashville, TN 37240. *Strong solidity for group factors from lattices in* SO(n, 1) *and* SU(n, 1).

Generalizing techniques found in Ozawa and Popa, "On a class of II_1 factors with at most one Cartan subalgebra, II" (Amer. J. Math., 2010), we show that the group factors of ICC lattices in $\mathrm{SO}(n,1)$ and $\mathrm{SU}(n,1)$, $n \geq 2$, are strongly solid. (Received September 17, 2010)

1067-46-1015 **Fernanda Botelho** and **Richard J. Fleming*** (flemi1rj@cmich.edu), 615 N. Lansing, Mt. Pleasant, MI 48858, and **James E. Jamison**. *Extreme points and isometries on vector-valued Lipschitz spaces.*

For a Banach space E and a compact metric space (X, d), a function $F : X \to E$ is a Lipschitz function if there exists $k > 0$ such that

$$\|F(x) - F(y)\| \leq kd(x, y) \text{ for all } x, y \in X.$$

The smallest such k is called the Lipschitz constant $L(F)$ for F. The space $\mathrm{Lip}(X, E)$ of all Lipschitz functions from X to E is a Banach space under the norm defined by

$$\|F\| = \max\{L(F), \|F\|_\infty\},$$

where $\|F\|_\infty = \sup\{\|F(x)\| : x \in X\}$.

Recent results characterizing isometries on these vector-valued Lipschitz spaces require the Banach space E to be strictly convex. We investigate the nature of the extreme points of the dual ball for $\mathrm{Lip}(X, E)$ and use the information to describe the surjective isometries on $\mathrm{Lip}(X, E)$ under certain conditions on E, where E is not assumed to be strictly convex. We make use of an embedding of $Lip(X, E)$ into a space of continuous vector-valued functions on a certain compact set. (Received September 17, 2010)

1067-46-1049 **Brian C. Hall*** (bhall@nd.edu), University of Notre Dame, Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556, and **Matt Cecil**. *Dimension-independent results on heat kernels.* Preliminary report.

An influential paper of Bruce Driver and Leonard Gross studies L2 spaces of holomorphic functions on complex Lie groups with respect to a heat kernel measure. This paper obtains various dimension-independent estimates, thus opening the door to a similar analysis on infinite-dimenional Lie groups, beginning in the work of Maria Gordina. I will discuss some recent dimension-independent results about heat kernels on arbitrary manifolds. This is joint work with Matt Cecil. (Received September 17, 2010)

1067-46-1285 **Lon H Mitchell*** (lmitchell2@vcu.edu). *Operators on the $\mathcal{L}_\infty$ spaces of Bourgain and Delbaen.*

In 1980, J. Bourgain and F. Delbaen constructed two classes of $\mathcal{L}_\infty$ spaces each exhibiting many surprising properties. For a Banach space in either of these classes we define a bounded shift-type operator which is an isometry when restricted to a certain hyperplane. (Received September 20, 2010)

1067-46-1347 **Marius Junge*** (junge@math.uiuc.edu), 1409 West Green Street, Urbana, IL 61801, and **Eric Ricard** and **Dimar Shlyahktenko**. *Non commutative diffusion semigroups.* Preliminary report.

The generator of a commutative diffusion semigroup is essentially given by a second order differential equation. Equivalent formulations have been found by Bakry and Emery in terms of differentiability conditions for the gradient, and the existence of a suitable Markov dilation. This is closely related to the martingale problem. We investigate those semigroups which are driven by a free brownian motion and characterize them in terms of the gradient form. The class turns out to be extremely rich. (Received September 20, 2010)

1067-46-1477 **Dietmar Bisch*** (dietmar.bisch@vanderbilt.edu), Vanderbilt University, Department of Mathematics, Nashville, TN 37240. *Subfactors and Planar Algebras.* Preliminary report.

Composition of subfactors is an effective way of constructing new subfactors using well-understood planar algebras via Popa's reconstruction theorem. I will describe some recent constructions using these ideas, and plan to report on some progress towards the classification of small index finite depth subfactors. (Received September 21, 2010)

1067-46-1496 **Upasana Kashyap*** (upasana.kashyap@citadel.edu), 171 Moultrie Street, MSC 131, Charleston, SC 29409. *A Morita theorem for dual operator algebras.*

We consider some new variants of the notion of Morita equivalence appropriate to algebras of Hilbert space operators which are closed in the 'weak* -topology' (or equivalently, which are dual spaces and known as dual operator algebras), and we will describe how the earlier theory of strong Morita equivalence due to Blecher, Muhly, and Paulsen, transfers to this 'weak* topology setting'. We will present our main theorem, that two dual operator algebras are weak*-Morita equivalent in our sense if and only if they have equivalent categories of dual operator modules. A key ingredient in the proof of our main theorem is W*-dilation, which connects the non-selfadjoint dual operator algebra with the W*-algebraic framework. (Received September 21, 2010)

1067-46-1519 **Jesse D. Peterson*** (jesse.d.peterson@vanderbilt.edu), Mathematics Department, Vanderbilt University, 1326 Stevenson Center, Nashville, TN 37240. *Cohomology on measure preserving equavalence relations.*

I will review some basic notions of representations and cocycles on measure preserving equivalence relations. I will then discuss some techniques from which we can obtain structural information of a measure preserving equivalence relation from its cohomology. (Received September 21, 2010)

1067-46-1604 **Matthew Cecil*** (mcecil@nd.edu), Department of Mathematics, 255 Hurley, Notre Dame, IN 46556, and **Brian Hall**. *From Dimension-independent Heat Kernel Estimates to Exceptional Sets.* Preliminary report.

The classical skeleton theorem states that a square integrable holomorphic function on a complex Wiener space is determined by its 'values' on the Cameron-Martin subspace. Similar results have been proven in the setting of infinite dimensional complex Lie groups endowed with a heat kernel measure by Gordina, Driver, and others. We describe additional generalizations of these results. This is joint work with Brian Hall. (Received September 21, 2010)

1067-46-1794 **Azita Mayeli*** (amayeli@citytech.cuny.edu), Room N707, 300 Jay Street, Brooklyn, NY 11201. *Homogeneous Besov spaces on the stratified Lie groups as generalized coorbit spaces.* Preliminary report.

In this talk, we first introduce a notion of homogeneous Besov space on the stratified Lie groups in terms of a Calderón type decomposition into band-limited tempered distributions, and then we prove a characterization and atomic decomposition for these spaces in terms of band-limited wavelets. We also show that these Besov spaces are generalized coorbit spaces that were developed by J. Christensen and G. Ólafsson. We conclude this talk with some open questions related to our studies.
This talk is a summary of two joint works: with Hartmut Führ and with Jens G. Christensen, Gestur Ólafsson. (Received September 21, 2010)

1067-46-2042 **Steve Avsec*** (savsec2@illinois.edu). *Hardy spaces associated with semigroups of operators.*

I shall introduce Hardy spaces associated to self-adjoint, completely positive operators on von Neumann algebras. The motivation of our research is to understand the boundedness of fourier multipliers on noncommutative L_p spaces. This talk is based on joint work with M. Junge and T. Mei. (Received September 22, 2010)

1067-46-2196 **S. Argyros**, **D. Freeman*** (freeman@math.utexas.edu), **R. Haydon**, **E. Odell**, **Th. Raikoftsalis**, **Th. Schlumprecht** and **D. Zisimopoulou**. *Embedding Banach spaces into spaces with very few operators.* Preliminary report.

The "scalar plus compact problem" asks if there exists a Banach space with the property that every bounded operator on the space is equal to a scalar times the identity plus a compact operator. This long outstanding problem was recently solved by S. Argyros and R. Haydon who constructed such a space Z with the additional property that Z^* is isomorphic to ℓ_1. It was then shown by D. Freeman, E. Odell, and Th. Schlumprecht that every Banach space, X, such that X^* is separable embeds into a Banach space Y such that Y^* is isomorphic to ℓ_1. We combine both of these constructions to prove that if X is a Banach space such that X^* is separable and ℓ_1 does not embed into X^*, then X embeds into a Banach space Z such that every bounded operator on Z is equal to a scalar times the identity plus a compact operator. (Received September 22, 2010)

1067-46-2288 **Kevin James Beanland*** (kbeanland@vcu.edu), 1930 Floyd Ave, Richmond, VA 23220. *Strictly singular operators between separable Banach spaces.*

Given Banach spaces X and Y a bounded linear operator T from X to Y is strictly singular (in short, T is in SS(X,Y)) if its restriction to any infinite dimensional subspace is not an isomorphic embedding. In 2009, Androulakis, Dodos, Troitsky and Sirotken used the Schreier families to define subclasses of strictly singular operators.

In this talk we study the ordinal rank induced by these subclasses. (Received September 22, 2010)

1067-46-2304 **Sarah E. Wright*** (swright@holycross.edu), Department of Mathematics & Computer Science, College of the Holy Cross, 1 College Street, Worcester, MA 01610. *Graph Algebras, Aperiodicity, and Condition (F).* Preliminary report.

The condition "every cycle has an entry" first appeared in the literature in Kumjian, Pask, and Raeburn's paper on Cuntz-Krieger algebras of directed graphs, where it was called Condition (L). It provides a necessary condition for simplicity of the associated graph algebra. This condition has been generalized to aperiodicity conditions in the theory of topological graphs (Katsura), k-graphs (Kumjian, Pask), and the unifying theory of topological k-graphs (Yeend). We'll discuss the details of these generalizations as well as the theorems associated with them. We'll then introduce a Condition (F) on the finite paths of a topological k-graph that is equivalent to the corresponding aperiodicity condition. Hence, we obtain a condition which is much easier to check than the aperiodicity of infinite paths, which we'll explore through some examples. (Received September 22, 2010)

1067-46-2424 **John D Jasper*** (jjasper@uoregon.edu), Department of Mathematics, 1222 University of Oregon, Eugene, OR 97403. *The Schur-Horn Theorem for Operators with Three Point Spectrum.*

We characterize the set of diagonals of the unitary orbit of a self-adjoint operator with three points in the spectrum. Our result gives a Schur-Horn theorem for operators with three point spectrum analogous to Kadison's result for orthogonal projections. (Received September 23, 2010)

47 ► Operator theory

1067-47-53 **Mihaela Manole*** (michaela2050@yahoo.com), 708 W.Palmetto Street, Apt #B, Florence, SC 29501. *Systems of Nonlinear Schrödinger Equations.*

Using the existence results from Lions and Magenes we establish existence results for the nonlinear perturbed Schrödinger operator systems via Perov, Schauder and Leray-Schauder fixed point theorems. The abstract framework are related to Lebesgue-Sobolev spaces. The proofs are based on the fixed point methods and we apply convergent to zero matrices method used in Precup. (Received June 30, 2010)

1067-47-176 **M Anthony Gilliam*** (zzwarg@gmail.com), University of Montana, Department of Mathematical Science MMAI01, Mathematics Building, Missoula, MT 59812, and **Jennifer Halfpap** (halfpap@mso.umt.edu), University of Montana, Department of Mathematical Sciences MMAI01, Mathematics Building, Missoula, MT 59812. *The Szegö Kernel for Certain Non-Pseudoconvex domains in $\mathbb{C}^2$.*

The Szegö projection operator associated with a domain Ω in $\mathbb{C}^n$ is of fundamental interest in complex analysis. Its action can often be expressed as integration against a distribution on $\partial\Omega \times \partial\Omega$ which is equal to a smooth function off of some exceptional set. Understanding the nature of this set and obtaining sharp size estimates on the kernel for points near this set is essential for understanding the mapping properties of the operator. The problem is fairly well-understood for pseudo-convex domain of finite type, where the exceptional set consists of the diagonal of $\partial\Omega \times \partial\Omega$. Comparatively little is known for non-psuedoconvex domains. In this talk, we discuss the latter for a subclass of domains in $\mathbb{C}^2$ and show, in particular, that the exceptional set contains points off of the diagonal. (Received July 28, 2010)

1067-47-272 **David P Blecher*** (dblecher@math.uh.edu), Department of Mathematics, University of, Houston, Houston, TX 77204-3008. *Operator algebras with contractive approximate identities.* Preliminary report.

We present some new results on operator algebras with contractive approximate identities. Some of this is joint work with Charles Read. (Received August 15, 2010)

1067-47-316 **Selcuk Koyuncu*** (sk476@drexel.edu), Drexel University, 3141 Chestnut st Korman Center, Department of Mathematics, Philadelphia, PA 19104, and **Hugo Woerdeman** (hugo@math.drexel.edu), Drexel University, 3141 Chestnut st Korman Center, Department of Mathematics, Philadelphia, PA 19104. *The Inverse of a Two-level Positive Definite Toeplitz Operator.*

The Gohberg-Semencul formula allows one to express the entries of nonsingular Toeplitz matrices using only a few entries (the first row and the first column) of the matrix,under some nonsingularity condition. In this paper we will provide a two variable generalization of the Gohberg-Semencul formula in the case of a positive definite two-level Toeplitz matrix with a symbol of the form $\frac{1}{|p|^2}$ where p is a stable polynomial of two variables. We also consider the case of operator valued two-level Toeplitz matrix. Numerical results are included. (Received August 19, 2010)

1067-47-324 **S Mukherjee*** (smukherj@uwyo.edu), 3322 Joanna Brunner Drive, APT. A14, Laramie, WY 82072, and **F Jafari** and **J E McInroy**. *On characterization of range spaces of composition operator on spaces of entire functions.*

The celebrated Paley-Wiener theorem naturally identifies the spaces of bandlimited functions with subspaces of entire functions of exponential type. Recently, it has been shown that these spaces remain invariant only under composition with affine maps. In this paper we characterize the subspaces of $L^2(\mathbb{R})$ generated by the action of composition operators on spaces of bandlimited functions. Extensions of these theorems to deBranges-Rovnyak spaces are also given. (Received August 22, 2010)

1067-47-351 **Chang-Pao Chen*** (cpchen@wmail.hcu.edu.tw), Department of Applied Mathematics, Hsuan Chuang University, Hsinchu, 30092, Taiwan, **Jin-Wen Lan** (d937210@oz.nthu.edu.tw), Department of Mathematics, National Tsing Hua University, Hsinchu, 30013, Taiwan, and **Dah-Chin Luor** (dclour@isu.edu.tw), Department of Applied Mathematics, I-Shou University, Ta-Hsu, Kaohsiung 84008, Taiwan. *The Muckenhoupt-type estimations for the best constants in multidimensional modular inequalities over spherical cones.* Preliminary report.

In this paper, we establish the Muckenhoupt-type estimation for the best constant C associated with the following multidimensional modular inequality over a spherical cone:

$$\left(\int_E \left\{\Phi\left(\int_{\tilde{S}_x} k(x,t)f(t)d\sigma(t)\right)\right\}^q d\mu\right)^{1/q} \le C\left(\int_E \left\{\Phi(f(x))\right\}^p d\nu\right)^{1/p},$$

where $f \in L^p_\Phi(d\nu)$ and $1 \le p,q \le \infty$. Similar results are also derived for the complementary integral operator. As a consequence, we give the n-dimensional weighted extensions of Levinson's modular inequality, extensions of Stepanov's and Heinig's results, generalizations of the Hardy-Knopp-type inequalities, and those for the Riemann-Liouville operator and the Weyl fractional operator. We also point out that our estimates are better than the known ones. (Received August 26, 2010)

1067-47-352 **Gelu F Popescu*** (gelu.popescu@utsa.edu), Department of Mathematics, The University of Texas at San Antonio, One UTSA Circle, San Antonio, TX 78249. *Joint Similarity to Operators in Noncommutative Varieties.*

We present several results on the joint similarity to n-tuples of operators in noncommutative varieties $\mathcal{V}_\mathcal{P} \subset B(\mathcal{H})^n$, where $\mathcal{P}$ is a set of noncommutative polynomials in n indeterminates and $B(\mathcal{H})$ is the algebra of all bounded linear operators on a Hilbert space $\mathcal{H}$. Several classical results concerning the similarity to contractions have analogues in our noncommutative multivariable setting. When $\mathcal{P}$ consists of the commutators $X_iX_j - X_jX_i$, $i,j \in \{1,\dots,n\}$, we obtain commutative versions of these results. (Received August 26, 2010)

1067-47-412 **Geoff R Goehle*** (grgoehle@email.wcu.edu), Stillwell 426, Cullowhee, NC 28723. *The Mackey Machine for Groupoid Crossed Products.*

We identify the spectrum of regular groupoid crossed products using the methodology of the Mackey Machine. Specifically, we show that given a regular groupoid G whose isotropy subgroupoid S has a Haar system, along with an action of G on a C^*-algebra A, then there is an action of G on the spectrum of the group crossed product bundle $A \rtimes S$ such that the spectrum of the groupoid crossed product $A \rtimes G$ is homeomorphic to the orbit space $A \rtimes S/G$ via induction. (Received September 01, 2010)

1067-47-427 **Gabriel T Prajitura*** (gprajitu@brockport.edu), Brockport, NY 14420. *Irregular orbits of operators.*

We will analyze orbits of operators for which the infimum of the norms is 0 and the supremum is infinity. (Received September 02, 2010)

1067-47-441 **Robert F. Allen*** (allen.rob3@uwlax.edu), University of Wisconsin - La Crosse, Department of Mathematics, La Crosse, WI 54601, **Flavia Colonna** (fcolonna@gmu.edu), George Mason University, Department of Mathematical Sciences, Fairfax, VA 22030, and **Glenn R. Easley** (geasley@sysplan.com), System Planning Corporation, 3601 Wilson Boulevard, Arlington, VA 22201. *Multiplication Operators between Lipschitz-Type Spaces of an Infinite Tree.*

We investigate the multiplication operators between the Lipschitz space $\mathcal{L}$ and weighted Lipschitz space $\mathcal{L}_w$ on an infinite tree T. These spaces are the discrete analogue to the Bloch space and weighted Bloch space on the unit disk, respectively. We characterize boundedness and compactness, and establish estimates on the operator norm and essential norm for multiplication operators on and between these spaces. We also study the multiplication operators between these spaces and L^∞, the space of bounded functions on T. Lastly we study the isometric multiplication operators on and between these spaces. (Received September 03, 2010)

1067-47-522 **Alvaro Arias*** (aarias@math.du.edu), Department of Mathematics, University of Denver, Denver, CO 80208, and **Frederic Latremoliere** (Frederic.Latremoliere@du.edu), Department of Mathematics, University of Denver, Denver, CO 80208. *Ergodic actions of convergent Fuchsian groups on quotients of the noncommutative Hardy algebras.*

We characterize the completely isometric automorphism group of some quotients of F_n^∞, the noncommutative Hardy algebras introduced by Popescu in 1990.

We use the remarkable result of Davidson and Pitts that the group of completely isometric automorphisms of F_n^∞ is $SU(n,1)$, the group of biholomorphic maps from the unit ball of C^n into itself. We also use the pseudohyperbolic metric of the unit ball of C^n to simplify some calculations, and we use a version of a Blaschke condition on the unit ball of C^n. The completely isometric automorphism group of the quotient algebra is characterized using the spectrum of the quotient and using theory of biholomorphic maps on the unit ball of C^n.

As a Corollary, we prove that if Γ is a discrete group of $SU(n,1)$ satisfying the version of the Blachske condition, then there exists a quotient of F^∞ with Γ as the completely isometric automorphism group, provided Γ is its own stabilizer. (Received September 08, 2010)

1067-47-539 **Ronald G. Douglas**, **Gadadhar Misra** and **Jaydeb Sarkar***, The University of Texas at San Antonio, Department of Mathematics, College of Sciences, San Antonio, TX 78249. *Hilbert modules and dilation theory.*

In this talk, we will discuss the question of which Hilbert modules over some natural algebras including the ball algebra, the disk algebra and the polynomial algebra in several variables have an isometric co-extension to a given "model" Hilbert module. Moreover, we will discuss a curvature inequality for quotient Hilbert modules, generalizing an earlier result for contractive Hilbert modules over the disk algebra. (Received September 08, 2010)

1067-47-580 **Paul S. Muhly*** (pmuhly@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242, and **Baruch Solel** (mabaruch@techunix.technion.ac.il), Department of Mathematics, Technion, 32000 Haifa, Israel. *Function Theory from Tensor Algebras.* Preliminary report.

Suppose M is a W^*-algebra, that E is a W^*-correspondence over M, and that $\mathcal{T}_+(E)$ is the tensor algebra of E. If σ is a normal representation of M on a Hilbert space H, then there is a W^*-correspondence over $\sigma(M)'$, denoted E^σ and called the σ-dual of E, such that elements of $\mathcal{T}_+(E)$ can be represented as $B(H)$-valued functions defined on the closed unit ball, $\overline{\mathbb{D}(E^\sigma)}$. The functions are continuous on $\overline{\mathbb{D}(E^\sigma)}$ and analytic on the open unit ball, $\mathbb{D}(E^\sigma)$, as $B(H)$-valued functions, but they have additional structure that we shall describe. We shall discuss the properties of these functions in several concrete settings, showing connections with the theory of rings of generic matrices, and we shall present a number of unsolved problems that we have found interesting. (Received September 10, 2010)

1067-47-593 **Ronald G. Douglas*** (rdouglas@math.tamu.edu), TAMU-3368, College Station, TX 77843=3368, and **Yun-Su Kim**, **Hyun Kwon** and **Jaydeb Sarkar**. *Canonical Models for Quasi-Free Hilbert Modules.*

One can interpret the canonical model of Sz.-Nagy and Foias for contraction operators in terms of quotients of Hardy Hilbert Modules. We study generalizations of such models in which the Hardy module is replaced by other related building-block Hilbert modules such as those defined by weighted Bergman spaces. We show that when the "quotient operator" is in the Cowen-Douglas class the associated hermitian holomorphic vector bundle can be represented as a vector bundle tensor product involving the characteristic function and the bundle for the building-block module. This identification enables one to calculate the curvature of the associated Chern connection in terms of the "characteristic operator function." In particular, one shows that the isomorphism of two such quotient modules is independent of the building block Hilbert module, which is the Hardy module in the classical case. (Received September 10, 2010)

1067-47-611 **Raul E Curto*** (rcurto@math.uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Operators Cauchy dual to 2-hyperexpansive operators: The multivariable case.* Preliminary report.

In joint work with Sameer Chavan, we introduce an abstract framework to study generating m-tuples, and use it to analyze hypercontractivity and hyperexpansivity in several variables. These two notions encompass (joint) hyponormality and subnormality, as well as the study of toral and spherical isometries; for instance, the Drury-Arveson 2-shift is a spherical complete hyperexpansion.

Our approach produces a unified theory that simultaneously covers toral and spherical hypercontractions (and hyperexpansions). As a byproduct, we arrive at a dilation theory for completely hypercontractive and completely hyperexpansive generating tuples. We can then analyze in detail the Cauchy duals of toral and spherical 2-hyperexpansive tuples. We also discuss various applications. (Received September 10, 2010)

1067-47-621 **Franz Luef*** (luef@math.berkeley.edu), Department of Mathematics, UC Berkeley, Berkeley, CA CA 94720. *Crossed products in Gabor analysis and Rieffel projections in rotation algebras.* Preliminary report.

We interpret the Walnut representation of Gabor frames in terms of crossed products associated to rotations of the circle, aka as rotation algebras. Furthermore we rephrase the construction of Rieffel projections in terms of Wexler-Raz biorthogonality relations for tight Gabor frames. Finally we emphasize the relevance of Wiener amalgam spaces for the construction of nice projections in rotation algebras. (Received September 11, 2010)

1067-47-636 **J William Helton*** (helton@ucsd.edu), Math Dept., UC San Diego, La Jolla, CA 92093. *Non-commutative Inequalities.*

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 positive on the domain where another polynomial q is positive (due to a growing list of authors).

B. classification of convex non-commutative polynomials, rational functions and varieties. There are shockingly few. (due to Dym Hay Helton McCullough Vinnikov; algorithms for symbolic computation Camino, Helton, de Oliveira Shopple, Slinglend).

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 12, 2010)

1067-47-650 **George R Exner*** (exner@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837. *Backwards weighted shifts and n-contractivity.* Preliminary report.

A Hilbert space operator T is n-contractive ($n = 1, 2, \ldots$) if $\sum_{i=0}^{n}(-1)^i C(n,i) T^{*i} T^i \geq 0$, where $C(n,i)$ is the usual binomial coefficient. We consider the adjoints A_x^* of weighted shifts A_x with weight sequence $\sqrt{\frac{1}{x}}, \sqrt{\frac{2}{x+1}}, \ldots$ for $x > 0$; the A_m^* with m integral and $m \geq 2$ were used by Agler as models for n-contractivity. We characterize when the Aluthge transform of A_x^* is 2-contractive and give related results, and provide a condition sufficient for the compression of A_x^* to a canonical co-invariant subspace of codimension m to be n-contractive. (Received September 12, 2010)

1067-47-653 **Anna Skripka***, skripka@math.ucf.edu, and **Denis Potapov** and **Fedor Sukochev**. *Applications of multiple operator integration.*

Multiple operator integration has been a powerful tool in the study of functions of operators and their derivatives. A prominent example is Potapov-Sukochev's proof of the fact that every Lipschitz function is operator Lipschitz in the non-commutative L^p-space, $1 < p < \infty$, associated with a semi-finite von Neumann algebra. We can also interpret this result as one on Taylor-type approximation for functions of operators. The talk will concentrate on estimates for higher order Taylor remainders (in the context of von Neumann algebras) and their application to mathematical physics obtained by means of multiple operator integration. (Received September 12, 2010)

1067-47-689 **Duane K Farnsworth*** (farnsworthd@marshall.edu), Department of Mathematics, Marshall University, One John Marshall Drive, Huntington, WV 25755. *Estimating Arbitrary Symmetric Norms.* Preliminary report.

Consider the ring of bounded operators on a complex, separable Hilbert space. Many questions regarding the membership of specific operators in those ideals known as the Schatten classes have been studied in the past. But, the Schatten classes are just one family of symmetrically-normed ideals. One can formulate similar membership questions wherein the Schatten classes are replaced by arbitrary symmetrically-normed ideals. However, the ability to answer such questions will most likely depend on being able to get decent estimates of arbitrary symmetric norms. This talk will describe one method for obtaining such estimates. This method is at the heart of some recent work that investigates the membership of Hankel operators on the Segal-Bargmann space in an arbitrary symmetrically-normed ideal. (Received September 13, 2010)

1067-47-692 **Elias Katsoulis*** (katsoulise@ecu.edu), 102 Kilby Dr, Greenville, NC 27858. *The c*-envelope of a tensor algebra revisited.* Preliminary report.

A few years ago Kribs and myself characterized the C*-envelope of a tensor algebra of a correspondence as the associated Cuntz Pimsner algebra (in the sense of Katsura). We revisit and revise that construction and as a consequence we obtain some recent results as a corollaries to our theory. (Joint work with E. Kalariadis.) (Received September 13, 2010)

1067-47-693 **Michael Jury*** (mjury@ufl.edu), Department of Mathematics, University of Florida, PO Box 118105, Gainesville, FL 32611-8105. *Commutative operator algebras and realizations of polynomials on domains in* $\mathbb{C}^n$. Preliminary report.

Let Ω be the unit ball of a norm on $\mathbb{C}^n$, and E any operator space whose unit ball at the scalar level is Ω. Inspired by results of Ambrozie-Timotin, Ball-Bolotnikov and Mittal-Paulsen, we consider operator algebras of functions on Ω whose unit balls admit transfer function realizations. Such a ball is characterized by a von Neumann-type inequality and can be interpreted as the unit ball of the universal commutative operator algebra generated by E. The focus of the talk will be on some interesting examples obtained by taking E to be a maximal or minimal operator space over $\mathbb{B}^n$ ($=\mathrm{ball}(\ell^2_n)$) and the polydisk ($=\mathrm{ball}(\ell^\infty_n)$). (Received September 13, 2010)

1067-47-721 **George R. Exner** (exner@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837, **Il Bong Jung** (ibjung@knu.ac.kr), Department of Mathematics, Kyungpook National University, Daegu, 702-701, South Korea, **Eun Young Lee*** (eunyounglee@knu.ac.kr), Department of Mathematics, Kyungpook National University, Daegu, 702-701, South Korea, and **Mi Ryeong Lee** (leemr@knu.ac.kr), Faculty of Liberal Education, Kyungpook National University, Daegu, 702-701, South Korea. *Partially normal composition operators relevant to weighted directed trees.*

We characterize properties including p-hyponormality and p-paranormality for composition operators arising from measurable transformations on weighted directed trees, in terms of a test at each node v involving the masses at nodes in a neighborhood of nodes near v. Also constructed are certain graphs $\mathcal{E}$ universal for p-hyponormality in that the neighborhood of any node in any graph yielding a p-hyponormal composition operator is a certain limit of neighborhoods in $\mathcal{E}$. These results are applied to some examples with particularly regular graph structures. (Received September 14, 2010)

1067-47-908 **Joseph A. Ball*** (joball@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123. *Multivariable Nevanlinna-Pick interpolation and connections with control theory.*

The connection between the standard H-infinity problem in control theory and Nevanlinna-Pick interpolation in operator theory was established in the 1980s, and has led to a fruitful cross-pollination between the two fields since. In the meantime, there have been a number of developments in extensions of Nevanlinna-Pick interpolation and the related commutant lifting theory to several variables (both commuting and noncommuting), while research in H-infinity control theory has moved on to the study of robust control for systems with structured uncertainties and to the analysis of multidimensional systems. In this talk we review these developments and indicate the precise connections which survive in the more general multidimensional/multivariable incarnations of the two theories. (Received September 16, 2010)

1067-47-1170 **Cyrus P. Aryana*** (aryana@svsu.edu), Department of Mathematical Sciences, Saginaw Valley State University, University Center, MI 48710. *A direct calculation of the vector Riemann constants corresponding to the marked doubles.*

When a multiply connected planar region D is the conjugate symmetric region obtained from the unit disc by removing $g \geq 1$ disjoint closed discs $D_1, \ldots, D_g$ centered on the real axis then the double X of such a region has the extra anticonformal involution map $Q : X \to X$ of reflection in the real axis. A direct calculation for the vector Riemann constants Δ_0 for such double X is given.

The calculation is made through marking X by a symmetric canonical homology basis, an earlier work of Gholamreza Akbari Estahbanati (now known as Cyrus P. Aryana) [Proc. of The Amer. Math. Soc., vol. 124, **9** (1996), 2737-2744]. (Received September 19, 2010)

1067-47-1262 **Ionut Chifan*** (ionut.chifan@vanderbilt.edu), 1320 Stevenson Center, Nashville, TN 37235. *Von Neumann algebras with unique Cartan subalgebras.*

In this talk I will survey some recent results regarding von Neumann algebras with unique group measure space Cartan subalgebras. Then I will discuss some applications to W^*-superrigidity. (Received September 20, 2010)

1067-47-1515 **Dan D. Pascali*** (dp39@nyu.edu), Courant Institute, New York University, 251 Mercer St, New York, NY 10012-1185. *A simple proof of Fredholm alternative for A-proper mappings.*

The characterization of Fredholm operators and a proof of Fredholm alternative by means of finite-dimensional linear algebra, due to A.G. Ramm in 2001, is extended to nonlinear A-proper mappings. The results are related to the equations involving Petryshyn operators, with applications to semilinear elliptic problems without oddness conditions. (Received September 21, 2010)

1067-47-1624 **Victor Kaftal*** (victor.kaftal@uc.edu), **Ping W Ng** and **Shuang Zhang**. *Finite sums of projections.*

In their paper "Ellipsoidal tight frames and projection decompositions of operators" in the Illinois J of Math. (2004) Dykema, Freeman, Kornelson, Larson, Ordower, and Weber investigate when is a positive Hilbert space operator the frame operator of an equal norm frame (equivalently, when is it a sum of rank one projections). A necessary and sufficient condition was presented by the authors in JFA (2009) in terms of the excess and defect part of the operator.

Harder is the question: when is a positive Hilbert space operator the frame operator of a finite union of orthonormal bases (equivalently, when is it a finite sum of projections).

A sufficient condition is that the essential norm of the operator is larger than one. We will mention several different proofs of this result. One of these proofs extends to Cuntz algebras ($n < \infty$) which are well-known in C*-theory.

A necessary condition is given through frame theory methods in terms of the principal ideals generated by the excess and defect parts of the operator. (Received September 21, 2010)

1067-47-1852 **Waleed Khaled Al-Rawashdeh*** (walrawashdeh@mtech.edu), Mathematical Sciences Department, Montana Tech of the University of Montana, 1300 West Park Street, Butte, MT 59701. *Schatten p-class Weighted Composition Operators on Bergman Spaces of the Unit Ball.*

Let φ be a holomorphic self-map of the unit ball $\mathbb{B}_n$ in $\mathbb{C}^n$ and let ψ be holomorphic function on $\mathbb{B}_n$. Then a weighted composition operator induced by φ with weight ψ is given by $\left(W_{\psi,\varphi}f\right)(z) = \psi(z)f(\varphi(z))$, for z in $\mathbb{B}_n$ and f holomorphic on $\mathbb{B}_n$.

A positive compact operator T on the weighted Bergman space $A^2_\alpha(\mathbb{B}_n)$ is in the trace class if

$$tr(T) = \sum_{n=1}^{\infty} \langle Te_n, e_n \rangle < \infty,$$

for some orthonormal basis $\{e_n\}$ of $A^2_\alpha(\mathbb{B}_n)$. If $0 < p < \infty$ and T is a compact operator on $A^2_\alpha(\mathbb{B}_n)$, then we say that T belongs to the Schatten p-class S_p if $(T^*T)^{p/2}$ is in the trace class.

It is known that weighted composition operators are related to Toeplitz operators on weighted Bergman spaces and Hardy space as well. We use this connection to Toeplitz operators, induced by positive measures and defined on the same space on which $W_{\psi,\varphi}$ acts, to characterize the Schatten p-class of weighted composition operators on weighted Bergman spaces. The results written in terms of the weighted φ-Berezin transform. (Received September 22, 2010)

1067-47-1952 **Damon M. Hay*** (dhay@shsu.edu), Sam Houston State University, Department of Mathematics, Box 2206, Huntsville, TX 77341. *Multipliers and hereditary subalgebras of operator algebras.* Preliminary report.

We generalize some technical results of Glicksberg to the realm of operator algebras which are not necessarily selfadjoint, and use them to prove a characterization of open and closed projections in terms of certain multiplier algebras. This generalizes a theorem of J. Wells characterizing ideals with contractive approximate identities in uniform algebras. (Received September 22, 2010)

1067-47-2149 **Dhruba R Adhikari*** (dadhikari@as.muw.edu), 1100 College Street, MUW-100, Columbus, MS 39701. *On the Uniqueness of Topological Degrees for Densely Defined Mappings Involving Variants of (S_+) Operators.* Preliminary report.

Let X be a separable reflexive Banach space, G a bounded open subset of X, and L a dense linear subspace of X. Then there is only one degree function $\mathrm{d}(A, G, 0)$ defined on the mappings $A : X \supset D(A) \to X^*$ satisfying Condition $(S_+)_L$ and invariant under certain homotopy. The existence of such a degree function is first established by Kartsatos and Skrypnik. Later, Berkovits used a different approach to construct the degree. (Received September 22, 2010)

1067-47-2425 **Genady Grabarnik*** (genadyg@hotmail.com), Scarsdale, NY 10583. *Orlicz spaces over real von Neumann Algebras.* Preliminary report.

We introduce Orlicz spaces over real von Neumann Algebras. For these spaces we establish a number of inequalities and based on them we show interpolation and limit theorems for the absolute contractions and expectations. (Received September 23, 2010)

49 ► *Calculus of variations and optimal control; optimization*

1067-49-85 **Cristina Popovici*** (cristina.popovici@ndsu.edu), Department of Mathematics, North Dakota State University, NDSU Dept. # 2750, P.O. Box 6050, Fargo, ND 58108-6050. *Γ-convergence of Power-Law Functionals and Applications to Polycrystal Plasticity.*

Models of polycrystal plasticity are obtained as limiting cases of more flexible power-law models via Γ-convergence. The effective yield sets are characterized in terms of variational principles in L^∞ associated to the limiting functionals. (Received July 20, 2010)

1067-49-209 **Xiao Chen*** (xc06@fsu.edu), Florida State University, Department of Scientific Computing, 400 Dirac Science Library, Tallahassee, FL 32306-4120, and **Santha Akella** (santha.akella@gmail.com) and **Ionel Michael Navon** (inavon@fsu.edu), Florida State University, Department of Scientific Computing, 400 Dirac Science Library, Tallahassee, FL 32306-4120. *A dual weighted trust-region adaptive POD 4D-Var applied to a Finite-Volume global shallow-water Equations Model in Sphere.*

In this work we study solutions of an inverse problem for a global shallow water model controlling its initial conditions specified from the 40-yr ECMWF Re-Analysis (ERA-40) datasets, in presence of full or incomplete observations being assimilated in a time interval(window of assimilation) with or without background error covariance terms. As an extension of the work in Chen et al., 2009, we attempt to obtain a reduced-order model of above inverse problem, based on proper orthogonal decomposition (POD), referred to as POD 4-D Var for a finite volume global shallow water equations model based on the Lin-Rood flux-form semi-Lagrangian semi-implicit time integration scheme. Different approaches of POD implementation of the reduced inverse problem are compared, including a dual-weighted method for snapshot selection coupled with a trust-region POD adaptivity approach. Numerical results with various observational densities and background error covariance operator are also presented. The POD 4-D Var model results combined with the trust region adaptivity exhibit similarity in terms of various error metrics to the full 4-D Var results, but are obtained using a significantly lesser number of minimization iterations and require lesser CPU time. (Received August 03, 2010)

1067-49-224 **Jonathan M Borwein*** (jon.borwein@gmail.com) and **Brailey Sims**. *Douglas-Ratchford iterations in the absence of convexity.*

The Douglas-Rachford iteration scheme, introduced half a century ago in connection with nonlinear heat flow problems, aims to find a point common to two or more closed constraint sets.

Convergence is ensured when the sets are convex subsets of a Hilbert space.

However, despite the absence of satisfactory theoretical justification, the scheme has been routinely used to successfully solve a diversity of practical optimization or feasibility problems in which one or more of the constraints involved is non-convex. As a first step toward addressing this deficiency, we provide convergence results for a proto-typical non-convex scenario.

This is joint work with Brailey Sims which is to appear in *Fixed-Point Algorithms for Inverse Problems in Science and Engineering* in the *Springer Optimization and Its Applications* series. A preliminary version is available at http://www.carma.newcastle.edu.au/~jb616/dr.pdf. (Received August 09, 2010)

1067-49-347 **Elena Constantin*** (constane@pitt.edu), Department of Mathematics, University of Pittsburgh at Johnstown, 450 Schoolhouse Road, Johnstown, PA 15904. *Second Order Necessary Conditions in Scalar Nonsmooth Set Constrained Optimization.*

We are concerned with the following optimization problem

$$F(\bar{x}) = \text{Local Minimum}\, F(x), \text{ subject to } x \in D, \tag{P}$$

where $F : X \to \mathbb{R}$, and D is an arbitrary subset of the Banach space X.

We develop second-order necessary conditions for problem (P) using the first and second-order upper generalized derivatives of the nonsmooth objective function F. Our optimality conditions are formulated in terms of Pavel and Ursescu's tangent cones to the constraint set at the extremum point. We describe the second-order tangent cones to equality and inequality constraint sets given by means of a functional G under various hypotheses on G.

We analyze an example to illustrate the applicability of our results. (Received August 25, 2010)

1067-49-398 **Frank Morgan*** (Frank.Morgan@williams.edu). *Isoperimetric Problems with Density.* Preliminary report.

A round sphere provides the least-perimeter way to enclose given volume in Euclidean space. What happens if you put a positive density on the space that weights both perimeter and volume, as used in Perelman's proof of the Poincare' Conjecture? We discuss some recent results and open questions. (Received August 31, 2010)

1067-49-447 **Natalia da Costa Martins*** (natalia@ua.pt), Departamento de Matematica, Universidade de Aveiro, Campus Universitario de Santiago, 3810-193 Aveiro, Portugal, and **Delfim F. M. Torres** (delfim@ua.pt), Departamento de Matematica, Universidade de Aveiro, Campus Universitario de Santiago, 3810-193 Aveiro, Portugal. *Variational theory on time scales including the delta indefinite integral.*

We prove necessary optimality conditions of Euler-Lagrange type for generalized problems of the calculus of variations on time scales with a Lagrangian depending not only on the independent variable, an unknown function and its delta derivative, but also on a delta indefinite integral that depends on the unknown function. Such kind of variational problems were considered by Euler himself and have been recently investigated in [Methods Appl. Anal. 15 (2008), no. 4, 427-435]. Our results not only provide a generalization to previous results, but also give some other interesting optimality conditions as special cases. (Received September 03, 2010)

1067-49-449 **Agnieszka B. Malinowska*** (abmalinowska@ua.pt), Department of Mathematics, University of Aveiro, 3810-193 Aveiro, Portugal, and **Delfim F. M. Torres** (delfim@ua.pt), Department of Mathematics, University of Aveiro, 3810-193 Aveiro, Portugal. *Generalized time scales and the Hahn quantum variational calculus.*

We introduce the Hahn quantum variational calculus. Necessary and sufficient optimality conditions for the basic, isoperimetric, and Hahn quantum Lagrange problems, are studied. We also show the validity of Leitmann's direct method for the Hahn quantum variational calculus, and give explicit solutions to some concrete problems. To illustrate the results, we provide several examples and discuss a quantum version of the well known Ramsey model of economics. (Received September 04, 2010)

1067-49-564 **Mohsen Razzaghi*** (razzaghi@math.msstate.edu), Department of Mathematics & Statistics, Mississippi State University, Mississippi State, MS 39762. *Numerical solution for nonlinear differential equations via combined block-pulse and orthogonal functions.*

Depending on the structure, the orthogonal functions may be widely classified into three families: The first includes sets of piecewise constant basis functions (PCBF), (e.g., block-pulse, Haar, Walsh, etc.). The second consists of sets of orthogonal polynomials (e.g., Chebyshev, Laguerre, Legendre etc.). The third are widely used sets of sine-cosine functions in the Fourier series. While orthogonal polynomials and sine-cosine functions together form a class of continuous basis functions, PCBF's have discontinuities or jumps. Among PCBF's, block-pulse functions are found to be very attractive, in view of their properties of simplicity and disjointedness. In this work, we present a new direct computational method to solve nonlinear differential equations. The approach is based of reducing the nonlinear differential equations into a set of algebraic equations by first expanding the candidate function as a hybrid function with unknown coefficient. The hybrid function which consists of combined block-pulse and orthogonal functions, are first introduced. Some properties together with illustrative examples are given. (Received September 09, 2010)

1067-49-568 **Boris Mordukhovich** (boris@math.wayne.edu) and **Nghia Tran*** (ttannghia@gmail.com). *Optimality Conditions in Semi-Infinite and Infinite Programming.*

The paper concerns the study of new classes of optimization problems of the so-called *infinite programming* that are generally defined on infinite-dimensional spaces of decision variables and contain *infinitely many* of equality and inequality constraints. These problems reduce to *semi-infinite programs* in the case of finite-dimensional spaces of decision variables. We extend the well-known Mangasarian-Fromovitz and Farkas-Minkowski constraint qualifications to these infinite programs. Under these conditions, we establish some formulas for the normal cone to the feasible set by using advanced tools of variational analysis and generalized differentiation. Then we derive first order optimality conditions for semi-infinite and infinite programs. The results obtained are new not only for the classes of infinite programs under consideration but also for their semi-infinite counterparts. (Received September 09, 2010)

1067-49-569 **Sunmi Lee*** (mathever@gmail.com), School of Human Evolution and Social Change, Arizona State University, Tempe, AZ 85282. *Modeling optimal age-specific vaccination strategies against pandemic influenza.* Preliminary report.

In the context of pandemic influenza, the immediate and effective implementation of control measures is of great concern for public health officials around the world. In particular, the role of influenza vaccines should be considered as part of any pandemic preparedness plan. In this paper, we use a mathematical model that incorporates age-structured transmission dynamics of influenza to evaluate optimal vaccination strategies in the context of the Spring 2009 A (H1N1) pandemic in Mexico. We extend previous work on age-specific vaccination strategies to time-dependent optimal vaccination policies by solving an optimal control problem with the aim of reducing the overall number of symptomatic cases over the course of a single pandemic wave. Optimal vaccination policies are computed and analyzed under different vaccination coverages and different transmissibility levels (R0). The results suggest that optimal vaccination can be achieved by allocating most vaccines to young adults (20-39 y) followed by school age children (6-12 y) in the Mexican population. In addition, our results underscore the need of an universal influenza vaccine since this leads to the minimization of the overall number of symptomatic cases. (Received September 09, 2010)

1067-49-575 **John A. David*** (jdavid@wooster.edu), Taylor Hall 312, 1189 Beall Ave., Wooster, OH 44691. *HIV Model Analysis, State Estimation and Optimal Control.*

We will present a nonlinear model for the dynamics of HIV infection. This model includes multiple target cells, multiple treatment methodologies and virus specific immune response. It will be shown how an optimal control based treatment strategy can stimulate the virus specific immune response. The dynamics of the model will be studied under this treatment schedule through the application of sensitivity equations and parameter identifiability. In light of the inexact nature of biological models and data measurement errors, we will show how stochastic estimation can be used as a tool to both track state dynamics and estimate unknown model parameters. With these two methodologies developed we will then implement a Receding Horizon based feedback control based treatment strategy. Finally we will look at a system level model of HIV with drug resistance and how system level models can be related to genetic level information. (Received September 10, 2010)

1067-49-662 **David George Caraballo*** (dgc3@georgetown.edu), Department of Mathematics and Statistics, 3rd floor, St. Mary's Hall, Georgetown University, Washington, DC 20057-1233. *Existence of surface energy minimizing partitions of space satisfying volume constraints and having independent surface energy density functions.*

I will present my proof of the existence of surface energy minimizing partitions of Euclidean space R^n (for n = 2,3,...), satisfying volume constraints, and with independent smooth surface energy densities satisfying BV-ellipticity. This work extends well-known results by Fred Almgren, who, in 1976, gave the first existence and regularity results for minimal partitions with volume constraints, using surface energy density functions which are all scalar multiples of a fixed smooth norm.

For many years, problems involving partitions of R^n have been of interest in mathematics, materials science, biology, image processing, and many other fields. It is natural to consider partitions of space into regions having specified volumes, as with materials of fixed volumes attempting to find a least-energy configuration (e.g., soap bubble clusters, immiscible fluids, polycrystals). Understanding, for instance, the possible singularities in energy minimizers would improve our insight into and ability to predict properties of polycrystalline materials, in which surface energy density functions are typically not scalar multiples of one another.

In this talk, I will focus on the existence proof but will also comment briefly on regularity of the minimizers. (Received September 13, 2010)

1067-49-681 **Nguyen Mau Nam*** (nguyenmn@utpa.edu), 1201 W. University Drive, Edinburg, TX 78539, and **Juan Salinas** (jsalinasn@broncs.utpa.edu), 1201 W. University Drive, Edinburg, TX 78539. *Variational Analysis of Minimal Time Functions and Applications.*

In this talk we present new results on our recent the study of a broad class of minimal time functions corresponding to control problems with constant convex dynamics and closed target sets in Banach spaces. We obtain formulas for computing various subgradients of minimal time functions in both cases of convex and nonconvex targets. Our technique is based on advanced tools of variational analysis and generalized differentiation. As an application, we introduce a generalized version of the celebrated Fermat-Torricelli problem and derive necessary as well as necessary and sufficient optimality conditions for the problem. Our approach allows us to completely solve this problem in many important settings. *(This talk is based on a joint work with Prof. Boris Mordukhovich)* (Received September 13, 2010)

1067-49-684 **Boris Mordukhovich**, 656 W. Kirby, Detroit, MI 48202, and **Nguyen Mau Nam*** (nguyenmn@utpa.edu), 1201 W. University Drive, Edinburg, TX 78539. *Applications of Nonsmooth Optimization to a Generalized Fermat-Torricelli Problem.*

In this talk we present new applications of generalized differentiation and nonsmooth optimization to the following optimization problem and its specifications: given n closed subsets of a Banach space, find such a point for which the sum of its distances to these sets is minimal. This problem can be viewed as an extension of the celebrated Fermat-Torricelli problem: given three points on the plane, find another point such that the sum of its distances to the designated points is minimal. Based on advanced tools and recent results of generalized differentiation and nonsmooth optimization, we derive necessary as well as necessary and sufficient optimality conditions for the extended version of the Fermat-Torricelli problem under consideration, which allow us to completely solve it in some important settings. Furthermore, we develop and justify a numerical algorithm of the subgradient type to find optimal solutions in convex settings and provide its numerical implementations. (Received September 13, 2010)

1067-49-697 **Ram U Verma*** (verma99@msn.com), Texas A&M University, Dept of Mathematics, 700 University Blvd, Kingsville, TX 78363. *Relatively Relaxed Proximal Point Algorithms for Generalized Maximal Monotone Mappings and Douglas-Rachford Splittings.* Preliminary report.

The maximal monotone set-valued mappings provide a powerful framework to study convex programming and variational problems. Based on the notion of relatively maximal monotonicity, the approximation solvability of a general class of variational inclusion problems is examined, while generalizing most of existing investigations on weak convergence using the proximal point algorithms in a real Hilbert space setting. We do observe that the obtained results can be applied to Douglas-Rachford splitting methods for finding the zero of the sum of two monotone mappings, as well as to Yosida approximations to the context of first-order evolution inclusions. (Received September 13, 2010)

1067-49-746 **Ana-Maria Croicu*** (acroicu@kennesaw.edu), 1000 Chastain Rd., Kennesaw, GA 30144. *Challenges of Control / Optimization Under Uncertainty.*

Problems of optimality or control under uncertainty occur frequently in a wide variety of real world problems in science, engineering and technology. A large number of problems such as engineering design, supply-allocation, production planning and scheduling, transportation, inventory network, and finance require that decisions be made in the presence of uncertainty. Uncertainty, for instance, governs the prices of fuels, the availability of electricity, and the demand for chemicals. This talk is dedicated to overview the current challenges of optimization / control under uncertainty. Even though this field has received special attention lately, much more can be done to address the numerous issues that can be raised. (Received September 14, 2010)

1067-49-773 **Hoang Dinh Nguyen*** (ndhoang@wayne.edu), Dept. of Mathematics, Wayne State University, 656 W. Kirby, Rm. 1150 Faculty and Administration Building, Detroit, MI 48202. *Discrete Approximations and Optimality Conditions for the Sweeping Process.*

We consider the optimal control problem relating to sweeping process where the differential inclusion which is given by the normal cone mappings is in non-Lipschitz cases. Mainly, we discuss the optimality conditions of the optimal solution of this problem. This talk is based on the joint work with Prof. Boris Mordukhovich (Department of Mathematics, Wayne State University, USA; boris@math.wayne.edu) and Prof. René Henrion (Weierstrass Institute for Applied Analysis and Stochastics, Germany: henrion@wias-berlin.de). (Received September 14, 2010)

1067-49-775 **Hung Phan*** (pmhung@wayne.edu), 5200 Anthony Wayne Drive, #505, Detroit, MI 48202. *A Generalized Newton's Method based on Graphical Derivatives.*

This paper concerns developing a numerical method of the Newton type to solve systems of nonlinear equations described by nonsmooth continuous functions. We propose and justify a new generalized Newton algorithm based on graphical derivatives, which have never been used to derive a Newton-type method for solving nonsmooth equations. Based on advanced techniques of variational analysis and generalized differentiation, we establish the well-posedness of the algorithm, its local superlinear convergence, and its global convergence of the Kantorovich type. Our convergence results hold with no semismoothness assumption, which is illustrated by examples. The algorithm and main results obtained in the paper are compared with well-recognized semismooth and B-differentiable versions of Newton's method for nonsmooth Lipschitzian equations. (Received September 14, 2010)

1067-49-858 **Kyle W. Fey*** (s-kfey2@math.unl.edu), 4151 Normal Blvd. Apt. 13, Lincoln, NE 68506, and **Mikil Foss**. *Morrey regularity for almost minimizers of nonconvex functionals with $p(x)$ growth.*

I will present global Morrey regularity results for minimizers of functionals with the form

$$u \mapsto \int_\Omega f(x, u(x), \nabla u(x))dx.$$

For each x and u, the function $F \mapsto f(x,u,F)$ is assumed to behave like $F \mapsto |F|^{p(x)}$ whenever $|F|$ is sufficiently large. These variational problems arise in certain models for electro-rheological fluids and thermistors. The regularity results are valid up to the boundary provided that the boundary data is sufficiently smooth. (Received September 15, 2010)

1067-49-937 **Ryan P Dunning*** (rdunning1@stmarytx.edu), One Camino Santa Maria, San Antonio, TX 78228. *Optimally Immersed Planar Curves under Möbius Energy.*

This lecture will outline the existence of optimally immersed planar self-intersecting curves. Because any self-intersecting curve has infinite knot energy, parameter-dependent renormalizations of the Möbius energy remove the singular behavior of the curve. The direct method of the calculus of variations allows for the selection of an optimal immersion in a certain class of curves. (Received September 16, 2010)

1067-49-945 **Suzanne Lenhart*** (lenhart@math.utk.edu), U of Tennessee, Math Dept, Knoxville, TN 37996, and **Rachael Miller Neilan**, Louisiana State University, Oceanography Dept, Baton Rouge, LA 70803. *Optimal control of a spatio-temporal epidemic model.*

We discuss optimal control of vaccination in spatio-temporal epidemic model using system of coupled parabolic partial differential equations. This model is applied to the distribution of vaccine baits to raccoons to slow the spread of rabies. Numerical solutions for optimal vaccine distribution will be illustrated using heterogeneous spatial domain. (Received September 16, 2010)

1067-49-1080 **Zhaohui Guo*** (annegzh@math.ucla.edu), University of California Los Angeles, Department of Mathematics, Box 951555, 520 Portola Plaza, Los Angeles, CA 90095, and **Stanley Osher** (sjo@math.ucla.edu), University of California Los Angeles, Department of Mathematics, Box 951555, 520 Portola Plaza, Los Angeles, CA 90095. *Template Matching via l_1 regularization with Application to Hyperspectral Imaging.*

Detecting and identifying targets or objects that are present in hyperspectral ground images are of great interest. Applications include land and environmental monitoring, mining, military, civil search-and-rescue operations, and so on. We propose and analyze an extremely simple and efficient idea for template matching based on l_1 minimization. The designed algorithm can be applied in hyperspectral classification, target detection and clustering. Synthetic image data and real hyperspectral image (HSI) data are used to assess the performance, with comparisons to other approaches, e.g. spectral angle map (SAM), adaptive coherence estimator (ACE), generalized-likelihood ratio test (GLRT) and matched filter. We demonstrate that this algorithm achieves excellent results with both high speed and accuracy by using Bregman iteration. (Received September 18, 2010)

1067-49-1132 **Elena Constantin*** (constane@pitt.du), Department of Mathematics, University of Pittsburgh at Johnstown, 450 Schoolhouse Road, Johnstown, PA 15904. *Second Order Necessary Conditions for Problems with Locally Lipschitz Data via Tangential Directions.*

The goal of this talk is to provide some second order necessary conditions of optimality for a constrained mathematical programming problem with locally Lipschitz data with the aid of Clarke's generalized derivative and Páles and Zeidan's second order upper directional derivative. There are given necessary conditions in terms of the quasi-interior directions and also necessary conditions in terms of the first and second order contingent directions to the constrained set at the extremum point. (Received September 19, 2010)

1067-49-1280 **Jakir Hossen** and **Ionel Michael Navon*** (inavon@fsu.edu), Dept of Scientific Computing, Dirac Sci Lib Bldg #483, Florida State Univer, Tallahassee, FL 32306-4120, and **Dacian N Daescu**. *Effect of random perturbations on adaptive observation techniques.*

An observation sensitivity method to identify targeted observations is implemented in the context of four dimensional variational (4D-Var) data assimilation. This methodology is compared with the well-established adjoint sensitivity method using a nonlinear Burgers equation as a test model. Automatic differentiation software is used to implement the first order adjoint model to calculate the gradient of the cost function required the 4D-Var minimization algorithm and adjoint sensitivity computations and the second order adjoint model to obtain the Hessian matrix of the 4D-Var cost required in the observation sensitivity computations. Numerical results indicate that the observation targeting is particularly successful in reducing the forecast error for moderate Reynolds numbers. The potential benefits of the observation sensitivity targeting approach over the adjoint sensitivity are investigated. The effect of random perturbations on the performance of adjoint sensitivity and observation sensitivity methods are also investigated. (Received September 20, 2010)

1067-49-1323 **Tao Wang*** (wang_t@math.psu.edu), 402 McAllister BLDG, Department of Mathematics, university park, PA 16802, and **Alberto Bressan**. *The Minimum Speed for a Blocking Problem on the Half Plane.*

We consider a blocking problem: fire propagates on a half plane with unit speed in all directions. To block it, a barrier can be constructed in real time, at speed σ. We prove that the fire can be entirely blocked by the wall, in finite time, if and only if $\sigma > 1$.

The proof relies on a geometric lemma of independent interest. Namely, let $K \subset R^2$ be a compact, simply connected set with smooth boundary. We define $d_K(x, y)$ as the minimum length among all paths connecting x with y and remaining inside K. Then d_K attains its maximum at a pair of points $(\bar{x}, \bar{y})$ both on the boundary of K. (Received September 22, 2010)

1067-49-1327 **Robert D Hill*** (rhill9@gmu.edu), 13304 Pennypacker Lane, Fairfax, VA 22033. *Modeling complex physical phenomena using energy minimization principle.* Preliminary report.

Modern modeling languages and optimization tools make it possible to analyze complex physical phenomena. The following two examples are driven by the energy minimization principle, and thus can be modeled using optimization: First, we consider a problem of docking a molecular wire to a bacterial photosynthetic reaction center (RC). To assemble efficient photovoltaic devices, it is critically important to explore how to dock highly conducting molecular wires to the RC. Second, we consider the problem of constructing phase diagrams. Phase diagrams illustrate the conditions in which thermodynamically distinct phases (e.g. gas, liquid or solid) can occur in equilibrium for a material or a mixture of materials. We build optimization models for both examples using AMPL and solve them using interior-point method and sequential quadratic optimization technique. (Received September 20, 2010)

1067-49-1382 **Akhtar A Khan*** (aaksma@rit.edu), School of Mathematical Sciences, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623, and **D E Ward**, Department of Mathematics and Statistics, Miami University, Oxford, OH 45056-1641. *Toward Second-Order Sensitivity Analysis in Set-Valued Optimization.*

This talk will focus on the use of second-order contingent derivatives and second order contingent epiderivatives to give a unified treatment of second order sensitivity analysis for set-valued and vector optimization problems. The second-order results recover a number of known results from first order sensitivity analysis as particular cases. Some new higher-order optimality conditions in set-valued optimization will also be discussed. (Received September 20, 2010)

1067-49-1386 **Miguel Sama*** (msama@ind.uned.es), Departamento de Matemática Aplicada, Universidad Nacional de Educación a Distanci, Calle Juan del Rosal, 12, 28040, Madrid, Spain, and **Akhtar A. Khan** (aaksma@rit.edu), School of Mathematical Sciences, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623. *A new topological condition for the existence of lagrange multipliers in set-valued optimization.*

In the recent years new multiplier rules for set-valued optimization problems have been given in terms of the derivative of scalarized maps. For the finite-dimentional case these rules are given for calm and convex data without assuming any differentiability assumption. This is not longer true even when the ordering cones have nonempty interior. In this work we present a new topological condition based on of the weak-interior of the ordering cones which allow us to extend the mutiplier rules from finite-dimentional space to more general infinite-dimentional spaces. The key result is a new estimate about the dual cones of weakly-solid cones. We show several examples showing that the hypotheses given are minimal. (Received September 20, 2010)

1067-49-1480 **Marcus R. Garvie**, Department of Mathematics and Statistics, MacNaughton Building, University of Guelph, Guelph, ON N1G 2W1, Canada, **Philip K. Maini**, Centre for Mathematical Biology, Mathematical Institute, 24-29 St. Giles', University of Oxford, Oxford, OX1 3LB, England, and **Catalin Trenchea*** (trenchea@pitt.edu), 301 Thackeray Hall, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *An efficient and robust numerical algorithm for estimating parameters in Turing systems.*

We present a new algorithm for estimating parameters in reaction-diffusion systems that display pattern formation via the mechanism of diffusion-driven instability. A Modified Discrete Optimal Control Algorithm (MDOCA) is illustrated with the Schnakenberg and Gierer–Meinhardt reaction-diffusion systems using PDE constrained optimization techniques. The MDOCA algorithm is a modification of a standard variable step gradient algorithm that yields a huge saving in computational cost. The results of numerical experiments demonstrate that the algorithm accurately estimated key parameters associated with stationary target functions generated from the models themselves. Furthermore, the robustness of the algorithm was verified by performing experiments with target functions perturbed with various levels of additive noise. The MDOCA algorithm could have important applications in the mathematical modeling of realistic Turing systems when experimental data are available. (Received September 21, 2010)

1067-49-1522 **Ryo Takei*** (rrtakei@ucla.edu), 520 Portola Plaza, Math Sciences Building 6363, Los Angeles, CA 90095. *Visibility based pursuit-evasion and related control problems.*

I present a novel algorithm to solve the visibility based pursuit-evasion problem, also known as the surveillance-evasion problem. The method uses the level-set function representation of the visibility from a vantage point in a domain containing arbitrary obstacles. I also discuss spin-off control problems, each of independent interest computational methods and robotics, that arises in generalizations of the aforementioned problem/algorithm. (Received September 21, 2010)

1067-49-1643 **Gisèle Mophou*** (gmophou@univ-ag.fr), Université des Antilles et de la Guyane, Laboratoire CEREGMIA, Campus Fouillole, 97159 Pointe-à-Pitre, Guadeloupe (FWI), 97159 Pointe à Pitre, Guadeloupe. *Optimal Control of Fractional Diffusion Equation.*

In this paper we apply the classical control theory to a fractional diffusion equation in a bounded domain. The fractional time derivative is considered in Riemann-Liouville sense. We first study the existence and the uniqueness of the solution of the fractional diffusion equation in a Hilbert space. Then we show that the considered optimal control problem has a unique solution. Interpreting the Euler-Lagrange first order optimality condition with an adjoint problem defined by means of right fractional caputo derivative , we obtain an optimality system for the optimal control. (Received September 21, 2010)

1067-49-1915 **Michele L Joyner*** (joynerm@etsu.edu), PO Box 70663, Johnson City, TN 37614. *Optimization Strategy for Single and Dual Resistance of Antibiotics in Hospitals.* Preliminary report.

Antibiotic resistance is a growing threat to public health and much effort is being made to reduce its overall spread. Toward this end, mathematical models have been designed to describe the transmission of resistant strains of bacteria within hospitals to better understand the effects of a variety of prevention techniques, including drug cycle times, drug mixing, and patient isolation. The models also take into account the potential presence of both single-resistance and/or multiple-antibiotic resistant strains of bacteria in the hospital setting. In this talk, I examine the problem of finding an optimal treatment regime which minimizes both single and dual antibiotic resistance within an inverse problem framework. (Received September 22, 2010)

1067-49-2124 **Bonnie Jacob*** (bcjntm@rit.edu). *Identification of nodes in a network: a discrete analogue of optical tomography.*

In this talk, we discuss a problem that consists of characterizing nodes as either “scattering” or “absorbing” in a network using the behavior of a signal on the network. We will also look at how initial conditions — i.e., the choice of sources– affect the ability to characterize the nodes. This discrete problem is based on the inverse problem of optical tomography, an imaging method. (Received September 22, 2010)

1067-49-2127 **Andreas H Hamel*** (hamel@yu.edu), Department of Mathematical Sciences, 2495 Amsterdam Avenue, New York, NY 10033. *Set-valued optimization revisited: From minimal points to lattice solutions.*

Motivated by duality issues for vector optimization problems, Corley and Luc introduced vector optimization problems with a set-valued objective in the 1980ies. In 1997, Tanaka, Ha and Kuroiwa initiated solution concepts based on extensions of the vector order to the power set of the underlying linear space. Recently, Hamel, Löhne and collaborators have shown that set-valued optimization (only) admits a complete (duality) theory parallel to the scalar case if lattice extensions both of image and pre-image space are used. This theory also matches the needs of recent applications in mathematical finance: optimization problems for set-valued risk measures for markets with transaction costs. The talk will be a guided tour through these subjects. (Received September 22, 2010)

1067-49-2309 **Animesh Chakravarthy**, **Katie A Evans**, **Johnny Evers** and **Lisa M Kuhn*** (lmk012@latech.edu), P.O. Box 10348, Ruston, LA 71272. *Target Tracking Strategies for a Nonlinear Aircraft Model.*

Aeroelastic wing micro aerial vehicle (MAV) concepts are being explored for military and civilian applications. However, on the whole, the issues of control of MAVs are largely unexplored. Distributed parameter modeling and control theory is employed in an effort to achieve agile flight potential of flexible, morphable wing MAV airframes. Two Euler-Bernoulli beams connected to a rigid mass are used to model an aeroelastic wing MAV. For realistic modeling, it is assumed that this multiple component structure is being acted upon by gravity and a nonlinear aerodynamic lift force. The focus of this talk is an effort to employ tools from linear distributed parameter control theory to gain insight into feasibly obtained wing shape, as a bridge to examining optimal wing morphing trajectories for achieving agile flight. (Received September 22, 2010)

1067-49-2316 **Monica Gabriela Cojocaru*** (mcojocar@uoguelph.ca), Dept. Mathematics & Statistics, 50 Stone Road East, Guelph, Ontario N1G 2W1, Canada. *Hybrid systems for variational inequalities.*

We relate variational inequalities, noncooperative games and hybrid dynamical systems so as to describe the disequilibrium evolution of an equilibrium problem (e.g. a dynamic network equilibrium problem or a dynamic game). We use a hybrid system with a switch & jump mechanism between continuous dynamic states given by a differential equation. The hybrid system also provides a way to analyze stability issues of hybrid solutions w.r.t. the problem's equilibrium states. (Received September 22, 2010)

1067-49-2395 **Harish Subrahmanya Bhat*** (hbhat@ucmerced.edu), 5200 N. Lake Rd., School of Natural Sciences, Merced, CA 95343. *Synthesis of two-dimensional electromagnetic media that achieve desired transfer functions.*

Consider Maxwell's equations in a two-dimensional, rectangular, inhomogeneous electromagnetic medium. If the permittivity and permeability everywhere in the medium are known, then we define the transfer function to be the operator that relates spatially varying, time-harmonic forcing on the left boundary to the steady-state solution on the right boundary. In this paper, we consider the inverse problem: to solve for the permittivity and permeability in a domain such that a prescribed transfer function is achieved. The problem is naturally posed as an optimization problem, for which the existence of minimizing sequences will be discussed. The continuum problem can be discretized in space using the method of finite volumes, resulting in an interesting design problem for an analog circuit comprising inductors, capacitors, and resistors. This discrete problem can be attacked using Newton and quasi-Newton methods; analytical expressions for gradients and Hessians can be computed using adjoint variables. We present numerical results that demonstrate the efficacy of the method, and we discuss potential applications in engineering. (Received September 23, 2010)

51 ► Geometry

1067-51-15 **Alexander Lubotzky*** (alexlub@math.huji.ac.il), The Hebrew University of Jerusalem, Jerusalem, Israel. *Expander graphs in pure and applied mathematics, III.*

The third lecture will be devoted to applications of expanders to geometry. The various equivalent definitions of expanders in the 1st lecture hinted toward seeing the expanding property as "an isoperimetric inequality". For a compact Riemannian manifold M, its fundamental group $\pi_1(M)$ has property (τ) (namely, its finite quotients Cayley graphs form a family of expanders) iff the finite sheeted covers of M satisfy a uniform isoperimetric inequality. This is a key observation (going back to Brooks) which enables to tackle some of the hardest geometric problems using expanders.

The main applications are toward Thurston conjecture on the non-vanishing of the first Betti number of finite sheeted covers of compact hyperbolic manifolds. It also tackles the conjecture that every compact hyperbolic 3-manifold has a finite sheeted cover which is Haken. After the work of Perelman, this is probably the most important open problem in the geometry of 3-manifolds.

If time permits we will also talk about the Baum-Connes conjecture. (A separate talk on this will be given by Paul Baum in the special session associated with these colloquium talks). (Received September 16, 2010)

1067-51-592 **Rebecca F Goldin*** (rgoldin@math.gmu.edu), MS 3F2, 4400 University Drive, Fairfax, VA 22030. *A Meeting of Algebra and Geometry in Decorated Graphs.*

How many different lines intersect four fixed lines generically placed in $\mathbb{R}$? Such questions in enumerative geometry have been translated into equivalent questions about the ring structure of algebraic invariants associated to some special symplectic manifolds. These algebraic questions have in turn been translated into combinatorial questions about an algebra associated to decorated graphs. We will show how this dictionary of works for a set of nice algebraic varieties and discuss how it can be generalized to a larger set of manifolds. (Received September 10, 2010)

1067-51-699 **Tara D Taylor*** (ttaylor@stfx.ca), Department of Mathematics, Statistics and CS, St. Francis Xavier University, Antigonish, NS B2G 2W5, Canada. *Using Cantor Sets to Study the Connectivity of Sierpiński Relatives.*

This paper presents an exploration of the connectivity of the class of fractals known as the Sierpiński relatives. The Sierpiński gasket (or triangle) is the most well-known relative. The relatives are attractors of iterated function systems that involve the same contractive mappings as for the gasket, combined with symmetries of the square. These relatives all have the same fractal dimension, but different topologies. Some are completely disconnected, some are simply-connected, and some are multiply-connected. For some of the relatives, one can determine the connectivity by considering certain Cantor sets that are subsets. These Cantor sets are variations of the usual middle thirds Cantor set, and can be viewed in binary or quaternary instead of ternary. (Received September 13, 2010)

1067-51-948 **Joseph Fera*** (jfera@wesleyan.edu), Department of Math and CS, 265 Church Street, Middletown, CT 06459. *On Exceptional Points of Cocompact Fuchsian Groups.* Preliminary report.

Let G be a cocompact Fuchsian group covering a compact hyperbolic surface of genus g. Beardon proved that the Dirichlet region for G based at z, $D(z)$, has $12g-6$ sides for almost every z in the hyperbolic plane H. Points z for which $D(z)$ does not have $12g-6$ sides are called exceptional and comprise a zero-measure subset of H. Using geometric and topological arguments, we prove that every cocompact Fuchsian group admits uncountably many exceptional points. Time permitting, we define "higher order" exceptional points and state their existence for cocompact G. (Received September 16, 2010)

1067-51-975 **Gregory N Hartman*** (hartmangn@vmi.edu), 427 Mallory Hall, Virginia Military Institute, Lexington, VA 24450, and **Daniel S Joseph**. *An Introduction to Generalized Parabolas I.* Preliminary report.

In this talk we examine generalized parabolas, an interesting class of curves which are the locus of points equidistant from a given point (the focus) and a (not necessarily affine) directrix. We discuss several of their properties, including a generalization of the well known reflection properties of conic sections. (Received September 17, 2010)

1067-51-976 **Daniel S Joseph*** (josephds@vmi.edu), 428 Mallory Hall, Virginia Military Institute, Lexington, 24450, and **Gregory N Hartman**. *An Introduction to Generalized Parabolas II.*

A generalized parabola is the locus of points equidistant from a given point (the focus) and a (not necessarily affine) directrix. Given an arbitrary curve, can we find a focus–directrix pair that generates it? In this talk we examine this question and the answer leads to some beautiful and fascinating curves. (Received September 17, 2010)

1067-51-1350 **Francois Labourie***, Batiment 425, 91405 Orsay, France. *What is a cross ratio?*
We shall explain what is a generalised cross ratio. We shall explain how a cross ratio is naturally associated to a (nice) representation of a surface group in $PSL(n, \mathbb{R})$ and why such an object gives interesting dynamical and symplectic information. (Received September 20, 2010)

1067-51-1442 **K.-D. Semmler*** (klaus-dieter.semmler@epfl.ch), SB-MATHGEOM, CH 1015 Lausanne, Switzerland. *Using Half turns for algorithms on hyper-elliptic Riemann surfaces.* Preliminary report.
Half-turns have given access to efficient geometric algorithms in presenting Riemann surfaces, in particular hyper-elliptic ones, in a minimal way. Also mappings between such surfaces can be understood in this way. We will give examples. (Received September 21, 2010)

1067-51-1552 **Stephon Alexander**, **Elaine Chew*** (echew@usc.edu), **Robert Rowe** and **Sam Rodriguez**. *The Pentahelix: a Four-Dimensional Realization of the Spiral Array.*
We propose to extend Chew's spiral array (2000), a geometric model for tonality, to four dimensions using simplical complexes so as to represent tetrachords. The spiral array represents pitch classes, triads, and keys as discretized helices embedded in three-dimensional space. Any discretized spiral, such as the pitch class helix in the spiral array, can be mapped into a tetrahelix. This map is not always one to one; the pitch class spiral, where adjacent pitches are seven half steps apart, maps to one tetrahelix, but a spiral in which adjacent pitch classes are only one half step apart maps to two tetrahelices. The building block of a tetrahelix is a tetrahedron, a 3-simplex. One full turn of the pitch class spiral corresponds to one full tetrahedron, and every triad corresponds to a specific face of the tetrahedron. We can make a linear chain of stacked tetrahedra by glueing faces of pairs of tetrahedral, and form a spiral by drawing a smooth curve connecting adjacent vertices of this chain. In a similar fashion, we can construct a pentahelix, a spiral chain of pentachorons (4-simplices) in four dimensions. We present the pentahelix extension of the spiral array and examine projections of the structure to lattices in two dimensions. (Received September 21, 2010)

1067-51-1616 **Mutlu Akar*** (makar@yildiz.edu.tr), Yildiz Technical University, Faculty of Arts, Sciences, Mathematics Department, Davutpasa Campus, Esenler, 34210 Istanbul, Turkey, and **Salim Yuce** (sayuce@yildiz.edu.tr), Yildiz Technical University, Faculty of Arts, Sciences, Mathematics Department, Davutpasa Campus, Esenler, Istanbul, 34210. *On the Generalizations of the Polar Moments of Inertia under the Homothetic Motions.*
In this study, during the 1-parameter closed homothetic motion, we give the Holditch-Type Theorems for the polar moments of inertia of the closed orbit curves. In the case of the homothetic scale: 1, the results given by Yüce, S., (2005) are obtained as a special case. (Received September 21, 2010)

1067-51-1688 **Rebecca F Goldin*** (rgoldin@math.gmu.edu), MS 3F2, 4400 University Drive, Fairfax, VA 22030, and **Susan Tolman** (stolman@math.uiuc.edu), 1409 W. Green Street, Urbana, IL 61801. *Positivity in the Symplectic Category.*
For flag varieties, the multiplicative coefficients of ordinary Schubert calculus are positive for (easy) geometric reasons. The equivariant cohomology and K-theory also satisfy a generalized notion of positivity (Graham, Kumar, Peterson, Buch, Anderson and others). For equivariant theories, there is also a notion of positivity given by the restriction of the cohomology classes to fixed points of a maximal torus action on the flag variety, and this also has been shown to be positive (Billey, generalized by Knutson). In this talk, I will what happens outside the algebraic category. This is joint work with Susan Tolman, University of IL, Champaign-Urbana. (Received September 21, 2010)

1067-51-1761 **Michael Follett**, **Catherine Pelland**, **Robert Won** and **Elizabeth McMahon*** (mcmahone@lafayette.edu). *SET® and disjoint complete caps in $AG(4,3)$.*
In the card game SET®, it is possible to have 20 cards containing no sets. These are the complete caps of the affine geometry $AG(4,3)$. We examine the structure of these caps as well as when it is possible for two caps to be disjoint. We find a decomposition of $AG(4,3)$ into disjoint complete caps and determine how such decompositions are permuted by the affine transformations. (Received September 21, 2010)

1067-51-1841 **Thomas Anthony Petrillo*** (thomas.petrillo@utoledo.edu), The University of Toledo, Department of Mathematics MS 942, 2801 W. Bancroft Street, Toledo, OH 43606. *Prime Paths in Graph Coverings and a Chebotarev Density-type Result.*

Let Y and X be finite graphs, with Y a covering graph of X. I establish a relationship between prime paths in Y and those in X. The proof will use combinatorial and analytic techniques. Additionally, a Chebotarev Density-type Theorem will be deduced. (Received September 22, 2010)

1067-51-1996 **Shing S So*** (so@ucmo.edu), Dept. of Math. & Comp. Sci., University of Central Missouri, Warrensburg, MO 64093. *Morley i$\triangle$, Morley e$\triangle$, and their Mother Triangle.*

Let $\triangle ABC$ denote any triangle. Then the triangles whose vertices are given by the points of intersection of the nearside trisectors of $\angle A$, $\angle B$, and $\angle C$ and the points of intersection of the nearside trisectors of the exterior angles at A, B, and C are two equilateral triangles. These triangles are sometimes referred as Morley $\triangle i$ and Morley $\triangle e$ since their vertices lie in the interior and exterior of the mother triangle $\triangle ABC$, respectively. In this paper, we discuss how the Morley $\triangle i$ and Morley $\triangle e$ can be used to characterize the mother triangle. (Received September 22, 2010)

1067-51-2031 **Matthew Drury*** (madrury@indiana.edu), 915 East Hillside Drive, Bloomington, IN 47401. *Einstein Submanifolds in a Kahler Space Form.*

In this talk we will survey the results of Calabi, Chern, Smyth and Umehara that address the problem of classifying all isometrically holomorphically immersed Einstein submanifolds of a Kahler space form. We will also give a short summary of the speakers efforts to generalize the work of these geometers. (Received September 22, 2010)

1067-51-2278 **Dennis Glenn Collins*** (d_collins_pr@hotmail.com), 1519 S. State Rd 119, Apt. 2, Winamac, IN 46996-8550. *Symmetry Analysis of Howe's Patterns.* Preliminary report.

Based on the author's algorithm to measure discrete and continuous symmetry, the symmetry of Howe's 60 (discrete)patterns is measured and compared with his pattern-goodness rating of visual patterns. The application of "probes" to evaluate symmetry is discussed in terms of elementary symmetric recognition operations, involving focusing on the distance between two points, then moving the eye to focus on the distance between two other points, and judging the distances are the same, i.e. there is a pair of equal distances. (Received September 22, 2010)

1067-51-2372 **Michael T Mara*** (mtm1@williams.edu), 63 St. James Ave., Chicopee, MA 01020, and **Yifei Li**, **Elena Wikner** and **Isamar Rosa**. *Perimeter-Minimizing Tilings with Penalties for Vertices.* Preliminary report.

In 2000, Hales famously proved the longstanding Honeycomb Conjecture: the regular hexagon tiling is the least perimeter way to tile the plane (and torus) with equal area tiles. We seek torus and planar tilings minimizing perimeter plus a vertex penalty and prove optimal properties of tilings by regular hexagons, squares and equilateral triangles for certain weighings of the vertex penalty. (Received September 22, 2010)

52 ► *Convex and discrete geometry*

1067-52-647 **Sandra Di Rocco**, KTH Stockholm, Department of Mathematics, 10044 Stockholm, Sweden, **Christian Haase**, FU Berlin, Mathematisches Institut, Arnimallee 3, 14915 Berlin, Germany, **Benjamin Nill*** (bnill@uga.edu), University of Georgia, Math Department, Boyd Building, Athens, GA 30602, and **Andreas Paffenholz**, TU Darmstadt, Fachbereich Mathematik, Schlossgartenstrasse 7, 64289 Darmstadt, Germany. *Polyhedral Adjunction Theory.*

In joint work with Sandra Di Rocco, Christian Haase and Andreas Paffenholz we study the adjunction theory of toric varieties from a polyhedral viewpoint. Essentially, 'polyhedral adjunction theory' is the question how a rational polytope P changes, when we move the facets of P by a constant value c > 0 inwards. More precisely, we define the adjoint polytope P(c) as the set of those points in P, whose lattice distance of any facet of P is at least c. In this talk I present the convex-geometric invariants corresponding to the spectral value and the nef value of a polarized toric variety associated to a lattice polytope P. Our main result shows that an n-dimensional lattice polytope P has lattice width one, if the adjoint polytope P(c) is empty for any c > 2/(n+1). If time allows, I will explain the relations to recent results in Ehrhart theory and on dual defect manifolds and state polyhedral versions of open questions in adjunction theory. (Received September 12, 2010)

1067-52-728 **Stephanie Vance*** (slvance@adams.edu), School of Sciences, Adams State College, 208 Edgemont Boulevard, Alamosa, CO 81102. *Improved sphere packing lower bounds from Hurwitz lattices.*

In this talk a new asymptotic lower bound will be given for the sphere packing density in dimensions divisible by four. This asymptotic lower bound improves on previous asymptotic bounds by a factor of $3/e$ and improves not just lower bounds for the sphere packing density, but also for the lattice sphere packing density and in fact, the Hurwitz lattice sphere packing density. Note that a Hurwitz lattice is a lattice in a quaternionic vector space which is closed under scalar multiplication by the Hurwitz integers $\mathbb{Z}[i, j, \frac{1+i+j+k}{2}]$. Moreover, the lattice sphere packing density for dimension n is directly proportional to the $(n/2)^{\text{th}}$ power of Hermite's constant γ_n, i.e., the supremum of the Hermite invariant computed over all n-dimensional lattices. (Received September 14, 2010)

1067-52-985 **Stoyu Barov** (stoyu@yahoo.com), Institute of Mathematics, Bulgarian Academy of Sciences, 8 Acad. G. Bonchev Str., 1113 Sofia, Bulgaria, and **Jan J. Dijkstra*** (dijkstra@cs.vu.nl), Afdeling Wiskunde, Vrije Universiteit, De Boelelaan 1081, 1081 HV Amsterdam, Netherlands. *On closed sets with convex shadows in Hilbert space.*

For a subset of the Hilbert space ℓ^2 its *shadows* are the orthogonal projections of the set onto hyperplanes. If $\mathcal{P}$ is a set of projection directions (unit vectors) then two sets are called $\mathcal{P}$*-imitations* of each other if they have identical shadows in all directions from $\mathcal{P}$. We present a number of results about closed sets in ℓ^2 that have convex shadows.

Theorem 1. *Let B be is a closed convex subset of ℓ^2 that does not contain a hyperplane and let $\mathcal{P}$ be a set of directions such that B is not an $(\operatorname{int}\overline{\mathcal{P}})$-imitation of B. If C is a closed $\mathcal{P}$-imitation of B such that $C \neq B$ then C contains a closed set that is homeomorphic to ℓ^2.*

For a set $B \subset \ell^2$ we let the *geometric interior* denote the interior of B with respect to the closed affine hull of B.

Theorem 2. *Let B be a closed convex subset of ℓ^2 with an empty geometric interior and let $\mathcal{P}$ be a somewhere dense set of directions. If C is a closed $\mathcal{P}$-imitation of B then $C = B$.*

We also discuss the construction of minimal imitations of closed convex sets that show among other things that Theorem 1 is sharp. (Received September 17, 2010)

1067-52-1141 **Lily Du**, **Stefanie Wang** and **Yonit Bousany***, Department of Mathematics and Statistics, Smith College, Northampton, MA 01063. *Experiments in monotone kinetic visibility.* Preliminary report.

Given a simple planar polygon, is it possible to move its vertices in such a way that the internal visibility graph increases monotonically? Mathematica experiments lead to possible approaches for answering this question, some of which can be proven to work for special subclasses. (Received September 19, 2010)

1067-52-1772 **Casey Mann*** (cmann@uttyler.edu), The University of Texas at Tyler, Department of Mathematics, 3900 University Blvd, Tyler, TX 75799. *Heesch Numbers of Polyforms with Edge Matching Rules.* Preliminary report.

The author presents the more interesting results of an extensive computerized search for the Heesch numbers of edge-marked polyforms. The Heesch number of a tile is the maximum number of layers formed from copies of the tile in a patch which may surround a centrally placed copy of the tile. A polyform of order n is a tile formed from n equilateral triangles, squares, or regular hexagons. In this study, the edges of polyforms were marked in various ways (matching colors, matching bumps and nicks, directed edges, and combinations thereof). (Received September 21, 2010)

1067-52-1959 **Eric L Grinberg*** (eric.grinberg@umb.edu), Department of Mathematics, University of Massachusetts Boston, 100 Morrissey Boulevard, Boston, MA 02125, and **David V. Feldman** (david.feldman@unh.edu), Department of Mathematics & Statistics, University of New Hampshire, Durham, NH 03824. *The Admissibility Problem for Radon transforms on projective spaces over finite fields.* Preliminary report.

We discuss I.M. Gelfand's Admissibility Problem for Radon transforms that "integrate" over subspaces of projective spaces over finite fields. A great deal is known about the uniqueness problem for these transforms, so it is natural to investigate uniqueness for extremally limited data sets, which is tantamount to the admissibility problem. Special cases suggest that the collection of analogs of Gelfand's Admissible Complexes is rich and varied. (Received September 22, 2010)

1067-52-2232 **Abhinav Kumar*** (abhinav@math.mit.edu), MIT Department of Math, Rm 2-169, 77 Massachusetts Avenue, Cambridge, MA 02139, and **Henry L Cohn** (cohn@microsoft.com) and **Achill Schuermann** (achill.schuermann@uni-rostock.de). *Lattices, periodic configurations and Gaussian potential energy.*

The potential energy of a lattice for the Gaussian potential $\exp(-2\pi cr^2)$ is essentially the value of its theta function $\theta(z)$ at $z = \sqrt{-1}c$. Similarly, the Gaussian potential energy for a periodic configuration is related to a value of its average theta function. Minimizing this function over the space of lattices or periodic configurations is a natural problem in physics, but also relevant to geometry (for instance, the limit as $c \to \infty$ is essentially the sphere packing problem). I will describe joint work with Henry Cohn and Achill Schürmann which performs computer simulations of gradient descent on spaces of periodic configurations with a small number of translates in low dimensions. This leads to counterexamples to conjectures of Torquato and Stillinger that the minima for energy are the densest lattices or their duals. We also find some other interesting phenomena such as the existence of formally dual periodic structures, which satisfy the analogue of Poisson summation for lattices. (Received September 22, 2010)

53 ► Differential geometry

1067-53-7 **Chuu-Lian Terng*** (cterng@math.uci.edu), Department of Mathematics, University of California, Irvine, CA 92697-3875. *Curves, surfaces, and solitons.*

The theory of soliton equations has been an active research area for the past forty-five years, with applications to algebra, geometry, mathematical physics, and applied mathematics. In this talk, I will explain how many of these equations arise as geometric evolution equations for curves and as the governing equations for surfaces in 3-space. In particular, I will use Quicktime movies and pictures produced in Palais' 3D-XplorMath mathematical visualization program to demonstrate properties of soliton equations and their associated geometric objects. (Received September 21, 2010)

1067-53-124 **Ryan L. Hotovy*** (ryan.hotovy@gmail.com), 203 Avery Hall, 880130, Lincoln, NE 68588, **Eileen R. Martin** (emartin@mail.utexas.edu), 1 University Station, C1200, Austin, TX 78712, and **Daniel Freeman**. *Continuously Moving Parseval Frames on Smooth Manifolds.* Preliminary report.

Moving bases on manifolds are important in the study of differential geometry and are applied in mathematical physics, but moving bases do not exist on all manifolds, for instance, the sphere. An alternative to a moving basis is a Parseval frame of unit-length vectors. We examine the existence of such frames on the Möbius strip, the Klein bottle, and n-dimensional spheres. We prove the existence of a continuously moving, unit-length Parseval frame on S^n when n is an odd integer. More generally, we investigate the relationship between the existence of a nowhere zero vector field and that of a continuously moving Parseval frame of unit length. One potentially useful tool in studying this relationship is the frame force associated with the frame potential. To better understand this possible method, we are led to a study of the dynamical properties of the frame force. (Received July 26, 2010)

1067-53-145 **Meghan Anne Galiardi** (mgaliardi@students.stonehill.edu), 14 Marshall St, Holliston, MA 01746, **Miguel Angel Lugo*** (mal08d@fsu.edu), 1712 The Woods Dr., Jacksonville, FL 32246, and **Shawn Leo Witte** (witte2sl@cmich.edu), 711 West Woodmeade Ct., Ada, MI 49301. *Facial Recognition Using Conformal Geometry.*

A 3-D scan of a face is taken and transformed into a hyperbolic surface with constant curvature using conformal geometry. The goal is to see if conformal geometry is useful in analyzing and distinguishing faces. Each vertex of the data is assigned a radius to create a circle packing metric. These radii are adjusted using Ricci flow to reduce the curvature of the face, yielding a smooth hyperbolic surface. Geodesics are extended from the boundaries of the hyperbolic surface until collisions occur, forming a ribbon graph. The shape of the ribbon graph and the length of its edges are used to provide a unique signature for the face. We will compare the signatures of different faces to determine the effectiveness of our methods. (Received July 27, 2010)

1067-53-166 **Thomas H. Wears*** (thwears@ncsu.edu), 2108 SAS Hall, North Carolina State University, Box 8205, Raleigh, NC 27695. *Moving Frames and The Equivalence of Homogeneous Polynomials.* Preliminary report.

The significance of Cartan's method of moving frames in applications to equivalence problems in differential geometry is well known. The method of moving frames as generalized by Fels, Olver and others allows for moving frames to be applied to a wide variety of equivalence problems. In this talk, I will show how combining the geometric method of moving frames with methods from classical algebraic invariant theory one can address the equivalence problem for multivariable polynomials under a linear change of variables. (Received July 28, 2010)

1067-53-193 **Paul T Allen** (ptallen@lclark.edu), Department of Mathematical Sciences, Lewis & Clark College, 0615 SW Palatine Hill Road, Portland, OR 97219, and **Adam Layne** (anlayne@gmail.com) and **Katharine Tsukahara*** (krtsukahara@gmail.com). *Distance comparison and the Dirichlet problem for curve shortening flow in convex domains.* Preliminary report.

The curve shortening flow, which evolves a curve in the normal direction with velocity proportional to its curvature, has been explored extensively for curves in the Euclidean plane. It is known that embedded, closed curves shrink to round points in finite time. The case of curves with fixed endpoints remains largely unexamined. In this setting a distance comparison theorem for plane curves due to Huisken can be used to investigate the long-time behavior of curves with fixed endpoints in convex regions of the plane. We also extend the distance comparison theorem to the case of curves on the sphere, where it can be used to analyze curves in convex regions. (Received July 29, 2010)

1067-53-765 **Artem Pulemotov*** (artem@math.uchicago.edu), Department of Mathematics, The University of Chicago, 5734 South University Avenue, Chicago, IL 60637. *Boundary conditions for the Ricci flow.*

The main objective of the talk is to propose new boundary conditions for the Ricci flow. Using these boundary conditions, we will state a series of short-time existence results. (Received September 14, 2010)

1067-53-1083 **Kenichi Maruno*** (kmaruno@utpa.edu), Department of Mathematics, The University of Texas - Pan American, 1201 W. Univ. Dr., Edinburg, TX 78539-2999, **Kenji Kajiwara**, Faculty of Mathematics, Kyushu University, Fukuoka, Japan, **Yasuhiro Ohta**, Department of Mathematics, Kobe University, Kobe, Japan, and **Bao-Feng Feng**, Department of Mathematics, The University of Texas - Pan American, Edinburg, TX. *The motion of discrete curves and the discrete hodograph transformation.*

The study of discrete curves is one of interesting topics in discrete integrable systems and discrete differential geometry. We show that a broad class of discrete integrable systems can be interpreted as equations describing the motion of discrete curves. The discrete hodograph transformations play an important role in this interpretation.

As examples, we discuss the discrete Short Pulse equation and the discrete WKI loop soliton equation. These equations are nothing but the Eulerian description of the motion of discrete curves. These equations are equivalent to the Lagrangian description of the motion of discrete curves which are described by the discrete Sine-Gordon equation and the discrete modified KdV equation, respectively. (Received September 18, 2010)

1067-53-1156 **Wah-Kwan Ku*** (wku@indiana.edu), 831 E 3rd Street, Rawles Hall, Bloomington, IN 47405, and **Marlies Gerber**, 831 E 3rd Street, Rawles Hall, Bloomington, IN 47405. *A dense G-delta of Riemannian metrics without the finite blocking property.*

A pair of points (x,y) in a Riemannian manifold (M,g) is said to have the finite blocking property if there is a finite set $P \subset M \setminus \{x,y\}$ such that every geodesic segment from x to y passes through a point of P. We show that for every closed C^∞ manifold M of dimension at least two and every pair $(x,y) \in M \times M$, there exists a dense G_δ set, $\mathcal{G}$, of C^∞ Riemannian metrics on M such that (x,y) fails to have the finite blocking property for every $g \in \mathcal{G}$. This is joint work with Marlies Gerber. (Received September 19, 2010)

1067-53-1222 **Jason Cantarella*** (jason@math.uga.edu), **Eric Rawdon** and **Albert La pointe**. *Computational results on tight composite knots.*

We report on recent large scale computer experiments on finding ”tight” or ”ideal” configurations for composite knots. Included will be a discussion of various local minima for the ropelength functional on knots discovered during our experiments. We will also discuss how our results support and challenge existing conjectures on the writhe and ropelength of conposite knots. (Received September 20, 2010)

1067-53-1232 **Donovan C McFeron*** (dmcferon@ramapo.edu), Ramapo College of New Jersey, 505 Ramapo Valley Rd, Mahwah, NJ 07430. *Remarks on some Non-Linear Heat Flows in Kähler Geometry.*

In this talk, we clarify or simplify certain aspects of the Calabi flow and of the Donaldson heat flow.

In particular, in 2002, Struwe studies the Calabi flow as a flow of conformal factors $g_{ij}(t) \equiv e^{2u(t)}\hat{g}_{ij}(0)$,

$$\dot{u}(t) = \frac{1}{2}\Delta R \tag{1}$$

and the convergence of the conformal factors $u(t)$ in the Sobolev norm $\|\cdot\|_{(2)}$ is obtained. Although the convergence of the conformal factors established by Struwe is only in the $\|\cdot\|_{(2)}$ norm, he states clearly that the convergence in arbitrary Sobolev norms, and hence in C^∞, should follow in the same way. In the first part of this talk, we confirm that this is indeed the case.

Next we discuss the Donaldson heat flow. We shall show directly the C^0 boundedness of the full curvature tensor $F_{\bar{k}j}{}^{\alpha}{}_{\beta}$ on $[0,\infty)$. Once again, our main technique is differential inequalities for the L^2 norms of the derivatives of $F_{\bar{k}j}{}^{\alpha}{}_{\beta}$, in analogy with the methods of Phong-Sturm, Szekelyhidi and the treatment of the Calabi flow that we used in the previous section. (Received September 20, 2010)

1067-53-1335 **James Vargo*** (vargo@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Local rigidity results for Riemannian metrics on a manifold with boundary.*

Consider a manifold with boundary that is endowed with a Riemannian metric. The boundary rigidity problem is to reconstruct the metric from boundary measurements of the geodesic rays. Linearizing leads one to an integral geometry problem of recovering a symmetric tensor from its integrals along geodesic rays. In this talk, we discuss results relating the linear problem to local rigidity for the non-linear problem. (Received September 20, 2010)

1067-53-1400 **Plamen Stefanov*** (stefanov@math.purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47906. *The geodesic X-ray transform in presence of caustics.*

We study the microlocal invertibility of the geodesic X-ray transform R in presence of conjugate points of fold type. We show that R^*R is a sum of a pseudo-differential operator and a Fourier Integral Operator. The Lagrangian of the later is the conormal bundle of the conjugate locus. We present results about cancelation of singularities, potential loss of stability and presence of "artifacts". The talk is based on a recent joint work with Gunther Uhlmann. (Received September 20, 2010)

1067-53-1954 **Peter Buser*** (peter.buser@epfl.ch), Ecole Polytechnique Fédérale, SB-IGAT-GEOM, Station 8, CH-1015 Lausanne, Switzerland, and **Hugo Parlier** (hugo.parlier@unifr.ch), Département de mathématiques, Université de Fribourg, Chemin du Musée 23, CH-1700 Fribourg, Switzerland. *Geometric estimates for the Birman-Series set.* Preliminary report.

Joan Birman and Caroline Series showed that in dimension two and (constant) negative curvature, the union set of all simple complete geodesics is nowhere dense. We present various new geometric estimates for this set and show pictures of interesting cases. (Received September 22, 2010)

1067-53-1958 **Susan Crook*** (sbcrook@ncsu.edu), NCSU Box 8205, Raleigh, NC 27695. *Curve Matching Using Integral Invariants.* Preliminary report.

As a result of its use in medical imaging, aerial photography, and handwriting recognition, curve matching is a significant problem in image analysis. Previous works propose integral invariants as a robust solution for the curve matching problem; however, the approximation techniques applied to these invariants generally result in non-invariant expressions.

We generate a method to systematically find invariant numerical approximations to the existing integral invariants. In this talk, we present examples of integral invariants and the corresponding invariant numerical approximations. (Received September 22, 2010)

1067-53-2114 **Arlo Caine***, 255 Hurley Hall, Notre Dame, IN 46556, and **Sam Evens**. *The Modular Class of Poisson Submersion.* Preliminary report.

Surjective Poisson submersions arise naturally in the theory of quotients in Poisson geometry. Using the Lie algebroid reformulation of the modular class of a Poisson structure, we study the behavior of the modular class under a Poisson submersion. (Received September 22, 2010)

1067-53-2183 **Joanna K Nelson*** (nelson@math.wisc.edu), 480 Lincoln Dr, Madison, WI 53706. *The Geometry of Simple Singularities.* Preliminary report.

We recall that a simple singularity may be characterized as the absolutely isolated double point quotient singularity of $\mathbb{C}^2/G$, where $G \subset SU_2$. The variety $\mathbb{C}^2/G$ may be realized as a hypersurface $f_G^{-1}(0) \subset \mathbb{C}^3$. An associated object of interest is the link K of a simple singularity, given by $S^5 \cap f_G^{-1}(0)$, which is diffeomorphic to S^3/G. We explain the natural contact structures associated to both K and S^3/G, and demonstrate that these are contactomorphic without using open book decompositions. We also discuss the associated strong symplectic fillings of the link given by the Milnor fiber and minimal resolution. The author is currently working on computing the (linearized) contact homology of the link, and will discuss her progress thus far. The talk will also be tailored to the audience's knowledge of symplectic and contact geometry. (Received September 22, 2010)

54 ► General topology

1067-54-264 **Christian Laing*** (cl84@biomath.nyu.edu), Courant Institute of Mathematical Sciences, Department of Chemistry, New York University, and **De Witt Sumners**, Department of Mathematics, Florida State University. *The writhe additivity formula and its applications to biomolecules.*

The writhe of a simple closed curve in 3-space is the signed average number of crossings seen when averaged over all directions in space. This important measure of entanglement has been widely used to model geometric and topological properties of biomolecules, and predict the functional biological outcomes form their structural configurations. The writhe of a polygonal curve can be computed as the sum of writhe increments coming from any two oriented edge segments composing the polygonal curve. By using this approach, the writhe can be extended to edge-oriented finite spatial graphs, spatial polygonal arcs and non-connected graphs. This generalization does not require the ad hoc closing of arcs to eliminate the problems posed by endpoints. I will discuss a new formula for the additivity of writhe for structures constrained to separate topological domains, and present some of these applications of the writhe to study properties of biomolecules such as DNA, RNA and proteins. (Received August 14, 2010)

1067-54-574 **Hueytzen J Wu*** (kfhjw00@tamuk.edu), Department of Mathematics, MSC 172, 700 University Blvd., Kingsville, TX 78363, and **Wan-Hong Wu**, 7703 Floyd Curl Dr., San Antonio, TX 78229. *Extensions of Tychonoff theorem in Hausdorff compactifications and generalized Stone-Weierstrass theorem.*

An extension of Tychonoff theorem to characterize compact spaces X is obtained in term of A-net, where A is any collection of continuous functions on X. The extension is applied in obtaining an arbitrary Hausdorff compactification of a Tychonoff space by a lattice-homomorphism process. This process results in an extension of the generalized Stone-Weierstrass theorem to Cz-vector lattices and Cz-algebras in the space of bounded real continuous functions on any topological space. (Received September 10, 2010)

1067-54-598 **Nick Scoville*** (nscoville@ursinus.edu), 153 Regents Rd., Collegeville, PA 19426. *The Advent of Point-Set Topology.* Preliminary report.

Point-Set topology was established as its own field in an 1872 paper by Georg Cantor. While some of the ideas in point-set topology had been around for decades, Cantor was the first to abstract them into the language of "point-sets." In this talk, we examine Cantor's 1872 paper to discover the subtle and ingenious way he solved a problem concerning trigonometric series representation of a function by introducing the concept of a point-set. (Received September 10, 2010)

1067-54-616 **Ina Petkova***, Department of Mathematics, Columbia University, Room 509, MC 4406, 2990 Broadway, New York, NY 10027. *Satellites of knots and bordered Heegaard Floer homology.*

We describe bordered Floer homology, defined by Lipshitz, Ozvath, and Thurston, in the case of torus boundary, and show a couple of applications to satellites of knots. (Received September 11, 2010)

1067-54-633 **Teresita Ramirez-Rosas*** (ramirezt@gvsu.edu), GVSU, 1 Campus Dr, A-2-178 MAK, Allendale, MI 49401. *A lower bound for the trisecants of a knot.* Preliminary report.

Let K be a polygonal knot. A triple abc is a *trisecant* of K if a, b and c are points in K, no two of which lie on a common edge of K, that are collinear, in this order, in $\mathbb{R}^3$.

In 1933, Erika Pannwitz proved that each point of K is the starting point of at least κ trisecants for K, where κ is the necessary number of boundary singularities for a disk in $\mathbb{R}^3$ bounded by K.

Fix $x \in K$ and let t_x denote the number of trisecants having x as an end point. We have show $t_x \geq \frac{2cr(K)+1}{3}$, where $cr(K)$ is the minimal crossing number of K. If we let x appear not only as an end point but also as a middle point in the trisecant, we have conjectured that $t_x \geq cr(K)$. In this talk, we will present our progress towards proving this conjecture. (Received September 12, 2010)

1067-54-760 **Scott W Williams*** (sww@buffalo.edu), Department of Mathematics, SUNY at Buffalo, Buffalo, NY 14260, and **Jocelyn R Bell** (Bell.Jocelyn@gmail.com), Department of Mathematics, SUNY at Buffalo, Buffalo, NY 14260. *The Uniform Box Product Problem.*

The uniform box product problem is a weakening of the well known box product problem which asks whether box products of certain compact spaces are paracompact or at least normal. At present, the Box Product problem has only consistent with ZFC affirmative ZFC answers. We will show, in ZFC, the uniform box product of a certain non-metrizable compact space is countably paracompact. (Received September 14, 2010)

1067-54-788 **Carolyn A Otto*** (co1@rice.edu), 3133 Buffalo Speedway, Apt #7304, Houston, TX 77098. *"The (n)-Solvable Filtration of the Link Concordance Group and Milnor's Invariants".*

I will give several results about the (n)-solvable filtration of the string link concordance group, denoted $\mathcal{F}_n$. First, I will establish a relationship between (n)-solvability of a link and its Milnor's $\bar{\mu}$-invariants. Using this, I will show the "other half" of the filtration, $\mathcal{F}_{n.5}/\mathcal{F}_{n+1}$, is nontrivial for links with sufficiently many components. Also, I will show that links modulo 1-solvability is a non-abelian group. Finally, I will show that $\mathcal{F}_n/\mathcal{G}_{n+2}$ is nontrivial for sufficiently many components. That is, the Grope filtration, $\mathcal{G}_n$ of the link concordance group is not the same as $\mathcal{F}_n$. (Received September 14, 2010)

1067-54-823 **Neil Hindman** and **Lakeshia R. Legette*** (llegette@jcsu.edu), 100 Beatties Ford Rd., Charlotte, NC 28216, and **Dona Strauss**. *The Number of Minimal Left and Minimal Right Ideals in βS.* Preliminary report.

Given an infinite discrete semigroup S, its Stone-Čech compactification βS has a natural operation extending that of S and making βS into a compact right topological semigroup. As such, βS has a smallest two sided ideal $K(\beta S)$, which is the union of all of the minimal left ideals and is the union of all of the minimal right ideals. It has been known that some weak cancellation assumptions on S guarantee the existence of many minimal left ideals and many minimal right ideals. We present here a couple of new results in that direction, but we are primarily interested in providing information about the existence of a large number of minimal right or minimal left ideals in an arbitrary semigroup (with no cancellation assumptions). For example, we show that for any infinite semigroup S, one of the following three statements holds: (1) S has a finite ideal, in which case $K(\beta S) \subseteq S$ and is finite; (2) βS has at least $2^{\mathfrak{c}}$ minimal left ideals; or (3) βS has at least $2^{\mathfrak{c}}$ minimal right ideals. (Received September 15, 2010)

1067-54-901 **Jan J. Dijkstra** and **Kirsten I. S. Valkenburg*** (kirstenvalkenburg@gmail.com), Dept of Mathematics and Statistics, McLean Hall, 106 Wiggins Road, Saskatoon, SK S7N 5E6, Canada. *On nonseparable Erdős type spaces.*

Let μ be an infinite cardinal and $p \geq 1$ and consider a Banach space ℓ^p_μ. An Erdős type subspace has the following form:

$$\mathcal{E}_\mu = \{x \in \ell^p_\mu : x_\alpha \in E_\alpha,\ \forall \alpha \in \mu\},$$

where $(E_\alpha)_{\alpha \in \mu}$ consists of subsets of $\mathbb{R}$.

Examples for $p = 2$ and $\mu = \omega$ are Erdős space, for which each $E_\alpha = \mathbb{Q}$ and complete Erdős space with each $E_\alpha = \{0\} \cup \{1/m : m \in \mathbb{N}\}$. These two spaces were introduced in 1940 by Erdős who showed that they are one-dimensional and homeomorphic to their own squares and hence important examples in dimension theory. They were characterized topologically by Dijkstra and van Mill.

In this talk we investigate Erdős type spaces $\mathcal{E}_\mu$ for μ uncountable and constructed with zero-dimensional sets E_α. Complete one-dimensional spaces of this kind can be classified as products of complete Erdős space and countably many discrete spaces, depending on two cardinal invariants of $\mathcal{E}_\mu$. One-dimensional spaces of this type with $F_{\sigma\delta}$-sets and infinitely many among them of the first category, can be classified as products of Erdős space and discrete spaces. Higher descriptive complexities are also discussed. (Received September 16, 2010)

1067-54-967 **Emily R Landes*** (elandes@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712. *Identifying the Canonical Component for the Whitehead Link.*

Although character varieties have proven to be a useful tool in studying hyperbolic 3-manifolds, only recently have explicit models for the $SL_2(\mathbb{C})$ character varieties of twist knot complements been constructed. As the twist knot complements can be obtained by Dehn filling one of the cusps of the Whitehead link complement, we are naturally interested in determining the canonical component of the Whitehead link character variety and studying the relationship among character varieties of manifolds obtained by Dehn surgery. In my talk I will show how the canonical component of the Whitehead link character variety is $\mathbb{P}^2$ blown-up at 10 points and discuss the canonical components for a few other hyperbolic 2-component link complements. (Received September 17, 2010)

1067-54-982 **Jocelyn R Bell*** (bell.jocelyn@gmail.com). *Normality of Uniform Box Products.*

The uniform box product problem is a weakening of the well known box product problem which asks whether box products of certain compact spaces are normal. Presently, the box product problem has only consistent with ZFC affirmative answers. We will show, in ZFC, the uniform box product of a certain non-metrizable compact space is both normal and collectionwise Hausdorff. (Received September 17, 2010)

1067-54-1349 **Aldo-Hilario Cruz-Cota*** (cruzal@gvsu.edu), 1 Campus Drive, A-2-178 MAK, Allendale, MI 49401. *Classifying Voronoi Graphs of Hex Spheres.*

A surface is called *singular Euclidean* if it can be obtained from a finite disjoint collection of Euclidean triangles by identifying pairs of edges by Euclidean isometries. The surface is locally isometric to the Euclidean plane except at finitely many points, at which it is locally modeled on Euclidean cones. These singular points are called the *cone points* and, in some sense, the curvature of the surface is concentrated at these points. For each cone point there is a *cone angle*, which is the sum of the angles of the triangles that are incident to the cone point.

A *hex sphere* is a singular Euclidean sphere with 4 cones whose cone angles are (integer) multiples of $\frac{2\pi}{3}$ but less than 2π. Given a hex sphere M, we consider its Voronoi decomposition centered at the two cone points with greatest cone angles. In this talk we use elementary Euclidean geometry to describe the Voronoi regions of hex spheres and classify the Voronoi graphs of hex spheres (up to graph isomorphism). (Received September 20, 2010)

1067-54-1385 **Aden O Ahmed*** (aden.ahmed@tamuk.edu), Department of Mathematics, MSC 172, 700 University BLVD, Kingsville, TX 78363-8202. *The Topological Structure of the Unit Octonions and the Quantum Theory of Games.*

We exploit the topological structure of the unit octonions in a quantized version of three player, two strategy games. The structure we exploit is a generalization of the usual "wedge" or "1-point union" of spheres to a construction where our family of spheres all intersect in a common sphere of lower dimension, a construction we call a "posy" of spheres. In the case of the octonions, such arise naturally among the many quaternionic subspaces embedded in the octonions. We find particular use for three embedded copies of the unit quaternions S3 that in the unit octonions S7 meet in a common copy of the unit complexes S1. (Received September 20, 2010)

1067-54-1521 **Jennifer McLoud-Mann*** (jmcloud@uttyler.edu), 3900 University Blvd., Tyler, TX 75799, **Casey Mann** (cmann@uttyler.edu), 3900 University Blvd, Tyler, TX 75799, and **David Milan** (dmilan@uttyler.edu), 3900 University Blvd., Tyler, TX 75799. *Stick Numbers in the Simple Hexagonal Lattice.*

We will discuss the minimum stick number in the simple hexagonal lattice. In particular, we answer the question, "what is the smallest number of sticks needed to construct a nontrivial knot whose corners lie in the simple hexagonal lattice?" (Received September 21, 2010)

1067-54-1854 **Mehrdad Namdari*** (namdari@ipm.ir), Department Of Mathematics, Shahid Chamran University, 61357 Ahvaz, Khoozestan, Iran. *A Generalization of Scattered spaces.*

$a-$scattered spaces are introduced and studied. It is shown that every continuous image of a compact Hausdorff $a-$scattered space X (i.e., every subset A of X with $|A| \geq a$ has an isolated point relative to A and a is the least regular cardinal with this property) is $b-$scattered for some $b \leq a$. Consequently, if X is a compact Hausdorff a-scattered space, where $a \leq c$ and c is the cardinality of continuum, then $a = \aleph_\circ$ the first infinite cardinal and X is scattered. Surprisingly, it follows that in any compact Hausdorff space X, every non-empty subset has an isolated point if and only if every uncountable subset of X has an isolated point. (Received September 22, 2010)

1067-54-1895 **Nigar Tuncer*** (nigar.tuncer@okan.edu.tr), Okan University, Istanbul, Turkey. *Inversible Fibrations.* Preliminary report.

In this work, we provide details about the inversible fibrations which has been defined by Dyer and Eilenberg but were not studied much since then. Dyer and Eilenberg defined fibrations which is the same as Hutewicz fibrations by using a different language, then they defined Inversible fibrations in this language. Inversible ones have homeomorphic fibers different then Hurewicz fibrations. We relate this type of fibrations to Hurewicz fibration and give further details. We study also inversibility of path space fibrations. By using some results we obtained, answer to triviality question is given. (Received September 22, 2010)

55 ► Algebraic topology

1067-55-273 **Amanda C Hager*** (amanda.hager@usma.edu), 240 Thayer Hall, West Point, NY 10996. *Freeness of Arrangement Bundles.*

A hyperplane arrangement is a finite collection of hyperplanes in any vector space. I investigate the relationship between the topology of the complement of an arrangement and certain algebraic objects related to an arrangement such as the module of derivations. In particular, Falk and Proudfoot conjectured that this module is well-behaved with respect to fibrations of the complement. I will give results toward this conjecture. (Received August 15, 2010)

1067-55-321 **William A. Sethares*** (sethares@ece.wisc.edu), Dept. Electrical and Computer Engineering, University of Wisconsin, 1415 Engineering Drive, Madison, 53706. *Topology of Musical Data.*

Techniques for discovering topological structures in large data sets are now becoming practical. This presentation argues why the musical realm is a particularly promising arena in which to expect to find nontrivial topological features. The analysis is able to recover three important topological features in music: the circle of notes, the circle of fifths, and the rhythmic repetition of timelines, often pictured in the necklace notation. Applications to folk music (in the form of standard MIDI files) are presented, and the bar codes show a variety of interesting features, some of which can be easily interpreted. (Received August 21, 2010)

1067-55-1030 **Kris J Williams*** (kjwillia@math.uiowa.edu), 97 S. Park Ridge Rd, North Liberty, IA 52317. *The homotopy type of the complement of an arrangement of hyperplanes.*

Consider an arrangement, a finite set of complex projective lines in the complex projective plane. One of the main areas of study in arrangement theory is determining how the intersections of the hyperplanes (combinatorics) affects the topology of the complement of the arrangement.

It is known that the combinatorics do not determine the topology in all cases. Rybnikov showed in 1993 that there exist two arrangements that have the same combinatorics, but the fundamental groups of complements of the arrangements are not isomorphic. In 1997, Fan defined a graph that is determined by the combinatorics of the arrangement. It is shown that if the graph is a forest of trees, then the fundamental group of the complement is a direct sum of free groups. The converse of this statement was proven by Eliyahu, Liberman, Schaps and Teicher in 2009.

In this talk we will show that any two arrangements in the projective plane with fundamental groups isomorphic to the same direct sum of free groups must have homotopy equivalent complements. We show that this occurs even though the combinatorics of the arrangements may differ. (Received September 17, 2010)

1067-55-1226 **Kate Ponto*** (kate.ponto@uky.edu), 719 Patterson Office Tower, University of Kentucky, Lexington, KY 40506. *Traces and topological fixed point theory.*

Fixed point theorems are very common in many areas of math. In algebraic topology, these results are often comparisons of invariants defined using different techniques. For example, the Lefschetz fixed point theorem is the identification of algebraic and geometric invariants. I'll describe an approach to these comparisons that is very different from the standard proofs. This perspective uses traces and has many advantages. One of the most important is that it generalizes easily. (Received September 20, 2010)

1067-55-1342 **Aaron David Valdivia*** (avaldivi@math.fsu.edu), 1306 1/2 B ML King Jr. Blvd, Tallahassee, FL 32303. *Asymptotics of minimal dilatation pseudo-Anosov mapping classes on rays in the gn-plane.*

A pseudo-Anosov mapping class is one that locally stretches a surface in one direction and contracts the surface in another, the stretching factor is called the dilatation. It is an open problem to determine the mapping class with minimal dilatation for a surface of genus g with n punctures. By considering a lattice we call the gn-plane and assigning each lattice point the minimal dilatation for a genus g surface with n punctures we can consider the asymptotic behavior of the minimal dilatations on rays in the gn-plane. In particular we expand known results to rational rays through the origin. (Received September 22, 2010)

1067-55-1365 **Mokhtar Aouina*** (mokhtar.aouina@jsums.edu), Jackson State University, Department of Mathematics, 1400 John R. Lynch Street, Jackson, MS 39217. *Applications of our generalized result of C. T. C Wall´s suspension theorem.*

In our work on moduli space of thickenings of a finite connected CW complex K, we generalized C. T. C. Wall´s suspension theorem by dropping the connectivity condition on K. As a result of this extension we can "compute" $\pi_0(T_n(K))$, the set of path components of the moduli space of n-thickenings, of a larger class of CW complexes. Given the challenge of computing $\pi_0(T_n(K))$, we will show through examples how our generalized result can provide an upper bound for the cardinality of $\pi_0(T_n(K))$. (Received September 20, 2010)

1067-55-1394 **Jeremy T Brazas*** (jtv5@unh.edu), 4 Forest Street, Newmarket, NH 03857. *The fundamental group as topological group.*

Recently, P. Fabel and J. Brazas have independently shown that viewing the fundamental group $\pi_1(X)$ as the quotient space of the loop space ΩX with the compact-open topology does not always give rise to a topological group. We use free topological groups to introduce a new group topology on the fundamental group. The resulting invariant π_1^τ takes values in the category of topological groups and is useful for studying homotopy in spaces that lack universal covers. This choice of topology allows us to prove topological analogues of classical results, which do not hold with the quotient topology. The preservation of products and a topological van Kampen theorem illustrate the potential for computation. Additionally, we realize an arbitrary topological group G as the fundamental group $\pi_1^\tau(Y)$ of a space Y obtained by attaching 2-cells to a "non-discrete wedge" of circles $\Sigma(X_+)$. (Received September 20, 2010)

1067-55-1437 **Muhammad N Ahmad*** (naeem@math.ksu.edu), Department of Mathematics, Kansas State University, Mahattan, KS 66506. *Complex N-Spin Bordism of Semifree Circle Actions and Elliptic Genera.*

We give the complete geometric description of rational bordism groups of compact complex N-spin manifolds admitting semifree circle actions. We find a computable condition under which a conjecture of Höhn [1], descrbing the ideal $I_*^{N,t}$ in rational complex N-spin bordism ring $\Omega_*^{U,N} \otimes \mathbb{Q}$ gererated by the bordims classes of complex N-spin manifolds admitting a semifree action of type t in terms kernels of elliptic genera of level N, is true. We apply the bordism analysis developed in this work to verify the condition for several values of N and t, and thereby prove the conjecture of Höhn for those values of N and t. Moreover, the machinery developed here gives a mechanism to explore the ideal $I_*^{N,t}$ for any given values of N and t in terms of kernels of elliptic genera of level N.

Refereneces:

[1] G. Höhn, *Komplex elliptische Geschlechter und S^1-äquivariante Kobordismustheorie,* Diplomarbeit, Bonn, 1991. (Received September 21, 2010)

1067-55-1664 **Michael P Allocca*** (alloccam2@scranton.edu), University of Scranton, Department of Mathematics, St. Thomas Hall 160, Scranton, PA 18510. *A Finite Dimensional L_∞ Module.*

L_∞ algebras are topics of current research. Representations of these structures are robust in nature and have yet to be explored in depth. L_∞ modules provide an alternative but equivalent way to describe representations. Concrete examples, however, remain elusive. We provide an example of a finite dimensional L_∞ module and discuss its implications. (Received September 21, 2010)

1067-55-1890 **Candice Renee Price*** (candice.r.price@gmail.com), 608 Ronalds st, Iowa City, IA 52245. *Oriented Skein Relation for HFK and Biological Applications.*

In *On the skein exact sequence for knot Floer homology*, Peter Ozsváth and Zoltán Szabó proved that there is a long exact sequence relating three knot diagrams that differ at a single crossing. We call these diagrams a *skein triple* denoted (K_+, K_-, K_0).

After looking at examples for this theorem, the following question arose: "What triples can be found where $K_\pm$ =Unknot?" This question is useful to answer due to its biological applications.

There exist proteins, *topoisomerase* and *recombinase*, that change the topology of DNA. These changes can inhibit or aid in biological processes involving the structure of DNA. *Topoisomerases* are proteins that cut one segment of DNA, passing a DNA segment through before resealing the break. The local action of these proteins can be modeled as a crossing change:

$$K_- \Leftrightarrow K_+.$$

Recombinase are proteins that cut two segments of DNA, and recombine them in some manner. We model this local action as a smoothing:

$$K_{\pm} \Rightarrow K_0.$$

We then view the triple as

$$K_{\pm} = \text{Unknot}, K_{\mp} = \text{topoisomerase action}, K_0 = \text{recombinase action}.$$

I will give a brief description of knot Floer homology and a biological application of the theorem described above. (Received September 22, 2010)

1067-55-1921 **Paul H Drube*** (pdrube@math.uiowa.edu), 15 MacLean Hall, Department of Mathematics, University of Iowa, Iowa City, IA 52242-1419. *Diffeomorphism Invariants from Topological Quantum Field Theories.*

Associated with every two-dimensional TQFT is a field-valued diffeomorphism invariant of closed, oriented two-manifolds, which we interpret as a map from the natural numbers to the base field. We precisely characterize which such maps may be realized as the diffeomorphism invariant of some 2-D TQFT. Our characterization is closely related to the question of whether the Frobenius algebra underlying a given TQFT is equivalent to the algebra of all 2-D surfaces having the circle as their boundary (taken modulo local skein relations as well as surfaces that "evaluate similarly"). We precisely characterize the class of TQFTs satisfying this property, and demonstrate that the set of functions arising as the diffeomorphism invariants of such TQFTs have a particularly simple description. (Received September 22, 2010)

1067-55-2133 **J Kyle Armstrong*** (j.kyle.armstrong@gmail.com), 406 Glenview Drive, Apt 7, Tallahassee, FL 32303. *Mixed Coxeter Systems.*

Here we present a generalization of Coxeter Systems by adding the signs +/- to Coxeter graphs. (Received September 22, 2010)

1067-55-2325 **Dan Lior*** (danlior2@uiuc.edu), 410 West Green Street, Apartment 4, Urbana, IL 61801. *The role of free Lie algebras in the Taylor tower of* Γ*-modules.* Preliminary report.

We present, for an arbitrary Γ-module F, a bicomplex $\Upsilon(F)$ whose columns are derived tensor products $Inj([n],-)_+\widehat{\otimes}_{\Sigma_n} cr_n F([1])$ of the functor of pointed injections out of a pointed n element set with the nth cross effect module of F. We give explicit descriptions of layers of the discrete Taylor tower for the Γ-module $Inj([n],-)_+$ and show how to use these layers together with ΥF to construct bicomplexes for all the layers of the discrete Taylor tower of F. In particular, the bicomplex for the first layer has intimate connections with certain free Lie algebras and the stable homotopy of F. These connections are described. (Received September 22, 2010)

57 ► Manifolds and cell complexes

1067-57-8 **Denis Auroux*** (auroux@math.berkeley.edu), University of California Berkeley, Department of Mathematics, 817 Evans Hall #3840, Berkeley, CA 94720-3840. *The symplectic geometry of symmetric products and invariants of 3-manifolds with boundary.*

About 10 years ago, Peter Ozsváth and Zoltán Szabó introduced new topological invariants of 3- and 4-dimensional smooth manifolds, defined in terms of Floer homology for product tori in symmetric products of Riemann surfaces. Over the years, a succession of advances have made these invariants ever more versatile and computable: Heegaard-Floer homology can be used to study knots, links, sutured manifolds, etc.; it has provided answers to many important questions in low-dimensional topology.

More recently, the introduction of *bordered Heegaard-Floer homology* by Robert Lipshitz, Peter Ozsváth and Dylan Thurston in 2008 has led to a much richer picture, in which these invariants fit into an extended topological field theory, associating algebras to surfaces and modules over these algebras to 3-manifolds with boundary. Recent work of Yankı Lekili and Tim Perutz further suggests a natural geometric interpretation of bordered Heegaard-Floer homology.

In this talk, we will try to present this circle of ideas from the perspective of the symplectic geometry of symmetric products of surfaces; our goal will be to show how sophisticated tools such as Fukaya categories can be used to explain the remarkable structure behind Heegaard-Floer theory. (Received September 08, 2010)

1067-57-258 **Patricia R Cahn*** (patricia.cahn@dartmouth.edu), 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755. *A Generalization of Turaev's Virtual String Cobracket and the Homotopy Rank of a Virtual String.* Preliminary report.

Turaev introduced a Lie cobracket on the free $\mathbb{Z}$-module generated by nontrivial homotopy classes of virtual strings. This cobracket gives an estimate on the minimal number of self-intersection points of a string in a given virtual homotopy class. We introduce an operation μ which can be viewed as a generalization of Turaev's cobracket, and this operation also gives an estimate on the minimal self-intersection number. We show that the estimate given by μ is better than the estimate given by Turaev's cobracket. We also provide a class of strings α such that $\mu(\alpha)$ gives an exact formula for the minimal self-intersection number of α rather than an estimate. (Received September 22, 2010)

1067-57-296 **Neil R Hoffman*** (nhoffman@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712. *Commensurability classes of hyperbolic knot complements and hidden symmetries.*

Two manifolds are commensurable if they share a common finite sheeted cover. In 2008, Reid and Walsh conjectured that there are at most three knot hyperbolic complements in a given commensurability class. Recently, Boileau, Boyer, Cebanu, and Walsh have shown that the conjecture holds in the case where there are no hidden symmetries. After introducing the necessary ideas, we will talk about the case where we assume hidden symmetries. (Received August 17, 2010)

1067-57-325 **Frank J Swenton*** (fswenton@middlebury.edu), Department of Mathematics, Warner Hall, Middlebury College, Middlebury, VT 05753. *An introduction to the Kirby Calculator.* Preliminary report.

After a brief presentation on the current state of the *Kirby Calculator* software for the computer manipulation of Kirby diagrams (and, along the way, knot diagrams), the author will field comments, suggestions, and questions from the attendees regarding the directions of future development of the project. A proof-of-concept version of this freely available software is available at http://www.kirbycalculator.net, currently very basic in its interface and features and only running under the Windows operating system; the next alpha version, to be completed by the time of the talk, will be further extended and will run seamlessly on both Windows and Macintosh systems. (Received August 22, 2010)

1067-57-335 **Morwen Thistlethwaite** and **Anastasiia Tsvietkova*** (tsvietkova@math.utk.edu). *Investigating hyperbolic link complements.* Preliminary report.

As a result of Thurston's Hyperbolization Theorem, many 3-manifolds have a hyperbolic metric or can be decomposed into pieces with hyperbolic metric (W. Thurston, 1978). In particular, Thurston demonstrated that every knot in S3 is a torus knot, a satellite knot or a hyperbolic knot and these three categories are mutually exclusive. It also follows from work of Menasco that an alternating link represented by a prime diagram is either hyperbolic or a (2,n)-torus link.

A new method for computing the hyperbolic structure of the complement of a hyperbolic link, based on ideal polygons bounding the regions of a diagram of the link rather than decomposition of the complement into ideal tetrahedra, was suggested by M. Thistlethwaite. Although the method is applicable to all hyperbolic links, it works particularly well for alternating (non-torus) links. The talk will introduce the basics of the method and its implementation. Original applications, such as investigating hyperbolic structure on specific link complements and a new algorithm for computation of hyperbolic volume, will be discussed. (Received August 23, 2010)

1067-57-383 **John R. Burke*** (jrburke@wesleyan.edu), John R. Burke, Middletown, CT 06457. *Genetic infection by string links and new structure of the knot concordance group.* Preliminary report.

In the talk, we will define the concordance group of knots and discuss the n-solvable filtration of this group defined by Cochran, Orr, and Teichner. We will then discuss some of the previous results about the structure of the concordance group, in particular, the structure of the abelian quotient groups, G_n, of n-solvable knots modulo $n.5$-solvable knots. We will end by discussing how by using genetic infection with string links and not knots alone one can construct knots in G_n which are linearly independent from previously studied knots. (Received August 30, 2010)

1067-57-497 **Tim D Cochran**, **Shelly Harvey** and **Peter D Horn*** (pdhorn@math.columbia.edu), Mathematics Department, MC4403, Columbia University, 2990 Broadway, New York, NY 10027. *Filtering smooth concordance classes of topologically slice knots.* Preliminary report.

We define several new filtrations of the smooth knot concordance group $\mathcal{C}$. The n-negative filtration $\{\mathcal{N}_n\}$ and n-positive filtration $\{\mathcal{P}_n\}$ are monoid filtrations of $\mathcal{C}$, and their intersection $\{\mathcal{NP}_n\}$ (where $\mathcal{NP}_n := \mathcal{N}_n \cap \mathcal{P}_n$) is a group filtration of $\mathcal{C}$ that refines the n-solvable filtration defined by Cochran-Orr-Teichner. We will present examples of knots lying in various filtration level, discuss the filtration's relationship with known concordance invariants, and state our main results. (Received September 07, 2010)

1067-57-505 **Ben M McCarty*** (benm@math.lsu.edu), Department of Mathematics, 303 Lockett Hall, Baton Rouge, LA 70803-4918. *Cube Number Distinguishes Legendrian Type for Certain Torus Knots.* Preliminary report.

For a knot K the cube number is a knot invariant defined to be the smallest n for which there is a cube diagram of size n for K. There is also Legendrian version of this invariant called the *Legendrian cube number*. We will show that the Legendrian cube number distinguishes the Legendrian left hand torus knots with maximal Thurston-Bennequin number and maximal rotation number from the Legendrian left hand torus knots with maximal Thurston-Bennequin number and minimal rotation number. (Received September 07, 2010)

1067-57-552 **Brandy J Guntel*** (bguntel@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712. *Primitive/primitive and primitive/Seifert representatives of knots.* Preliminary report.

Berge described a class of knots that lie on the genus 2 surface F in S^3 which are primitive/primitive with respect to F and observed that surgery on these knots yields lens spaces. Later Dean generalized this concept to introduce knots that are primitive/Seifert with respect to F and observed that primitive/Seifert knots have small Seifert fibered surgeries. I will provide an introduction to these families of knots and answer some questions about uniqueness of primitive/primitive and primitive/Seifert representatives of knots. (Received September 09, 2010)

1067-57-629 **Jennifer Hom*** (jenhom@math.upenn.edu). *The knot Floer complex, cabling and concordance.* Preliminary report.

We will use the bordered Heegaard Floer package of Lipshitz, Ozsváth and Thurston to give a formula for τ of the (p, q)-cable of a knot K in terms of p, q, and two smooth concordance invariants, τ and ε, associated to the knot Floer complex of K. We will discuss various properties of ε, including applications to the knot concordance group. (Received September 12, 2010)

1067-57-639 **Patricia Cahn*** (patricia.cahn@dartmouth.edu), 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755. *A Generalization of the Turaev Cobracket and the Minimal Self-Intersection Number.*

Goldman and Turaev constructed a Lie bialgebra structure on the free Z-module generated by free homotopy classes of loops on a surface. The Turaev cobracket Δ gives a lower bound on the minimum number of self-intersection points of a loop in a given homotopy class. Chas found examples which prove that this lower bound is not sharp in general. In particular, she constructed a class α such that $\Delta(\alpha) = 0$, where α is not realized by a power of a simple loop. This disproves a conjecture of Turaev. We introduce an operation μ, defined in the spirit of the Andersen-Mattes-Reshetikhin algebra of chord diagrams. The Turaev cobracket factors through μ, and μ also gives a lower bound on the minimal number of self-intersection points of a loop in a given homotopy class. We show that this lower bound is sharp, so that μ gives a formula for the minimal self-intersection number. We also show that an analogue of Turaev's conjecture holds for μ. (Received September 12, 2010)

1067-57-675 **Joan E Licata*** (jelicata@stanford.edu) and **Joshua M. Sabloff**. *Legendrian contact homology in Seifert fibered spaces.*

Seifert fibered spaces can be viewed as circle bundles over surface orbifolds. We consider the case when these manifolds can be equipped with contact forms whose Reeb orbits realize the Seifert fibers, and we define an invariant for the Legendrian knots in these contact manifolds. Our invariant takes the form of a differential graded algebra, and it can be computed combinatorially from an appropriately labeled Lagrangian projection. (Received September 13, 2010)

1067-57-682 **Matthew B. Day*** (mattday@caltech.edu), Mathematics 253-37, Caltech, Pasadena, CA 91125. *Stable commutator length and maps from bounded surfaces to closed surfaces.*

I will discuss an algorithm for computing stable commutator length in surface groups. This algorithm conjecturally always works, and definitely finds extremal surface maps whenever they exist. The algorithm uses linear programming and a combinatorial model for maps from surfaces with boundary to closed surfaces that represents surface maps as graphs. (Received September 13, 2010)

1067-57-744 **John Etnyre** and **David Shea Vela-Vick*** (shea@math.columbia.edu), 2990 Broadway, MC 4403, New York, NY 10027, and **Rumen Zarev**. *Reconstructing* HFK^- *from sutured Floer homology.*

I plan to discuss a method for reconstructing $\mathrm{HFK}^-(Y,K)$ as a direct limit of certain hat homology groups associated to the knot K, each equipped with a naturally defined U-action. Generalizing the techniques used in this construction, one can define useful invariants of contact structures on open 3-manifolds with $\Sigma^2\times[0,\infty)$-ends and appropriate boundary data at infinity. In this talk, I'll focus on the construction and discuss applications if time permits. (Received September 14, 2010)

1067-57-759 **Heather M. Russell*** (hrussell@math.lsu.edu). *The topology of Springer varieties.*

In recent years, Springer varieties have appeared with increasing frequency in the study of knot theory especially connected to categorified knot invariants. We will discuss a topological model for two-row Springer varieties that generalizes work of Khovanov and leads to a diagrammatic and skein-theoretic formulation of the Springer representation. We will also discuss progress towards developing a topological model for three-row Springer varieties. (Received September 14, 2010)

1067-57-763 **Cody Armond*** (carmond@math.lsu.edu), 303 Lockett Hall, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918. *Walks along Braids and the Colored Jones Polynomial.* Preliminary report.

We investigate the coefficients of the colored Jones Polynomial for alternating braids and positive braids. The method used is a reinterpretation of the quantum determinant description introduced by Vu Huynh and Thang Lê in terms of walks along the braid. This method can also be used to get closed formulas for the Colored Jones Polynomial of certain knots including all (2,p)-torus knots. (Received September 14, 2010)

1067-57-783 **Oliver Dasbach***, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Examples of the head and the tail of the colored Jones polynomial.* Preliminary report.

For certain classes of knots the generating function of the n-th coefficient of the n-th colored Jones polynomial has interesting properties. We will discuss examples. (Received September 14, 2010)

1067-57-825 **Cameron McA. Gordon*** (gordon@math.utexas.edu), Department of Mathematics, University of Texas, 1 University Station, C1200, Austin, TX 78712, and **Steven Boyer** and **Xingru Zhang**. *Seifert fibered Dehn filling.* Preliminary report.

Much is known now about hyperbolic 3-manifolds with pairs of non-hyperbolic Dehn fillings. The situation that is least understood is when one of the fillings is a Seifert fibered space. We will discuss work in progress on the case where one of the fillings is Seifert fibered and the other is toroidal. (Received September 15, 2010)

1067-57-835 **Prudence Heck*** (Prudence.Heck@rice.edu), Department of Mathematics, Rice University, 6100 S. Main St., Houston, TX 77005. *Concordance within a fixed homotopy class.*

We consider algebraic properties of knots in non-simply connected manifolds and use these to obstruct concordance. (Received September 15, 2010)

1067-57-857 **Danielle O'Donnol** and **Elena Pavelescu*** (ep6@rice.edu), Rice University, Mathematics MS - 136, 6100 S Main Street, Houston, TX 77005. *On Legendrian Graphs.* Preliminary report.

We study Legendrian embeddings of spatial graphs in a contact manifold. We look for necessary and sufficient conditions for Legendrian isotopy. (Received September 15, 2010)

1067-57-865 **Danielle S. O'Donnol*** (odonnol@rice.edu), Math Department – MS 136, Rice University, 6100 S. Main St., Houston, TX 77005. *Invariants of spatial graphs.*

A natural extension of knot theory is the study of spatial graphs. A *spatial graph* is an embedding of a graph into $\mathbb{R}^3$ or S^3. A spatial graphs can contain nontrivial knots and links as subgraphs. I will discuss my recent results in the area of spatial graphs. (Received September 15, 2010)

1067-57-871 **Dorothy Buck*** (d.buck@imperial.ac.uk), Dept of Mathematics, Imperial College London, London, SW7 2AZ, England, and **Ken Baker**. *The Classification of Rational Tangle Adjacencies, with Applications to Complex Nucleoprotein Assemblies.*

Many proteins cleave and ligate DNA molecules in precisely orchestrated ways. Modelling these reactions has often relied on the underlying DNA molecule being covalently closed, so these cut-and-seal mechanisms can be tracked by corresponding changes in the knot type of the DNA axis. However, in the (common) case when the DNA molecule is linear, or the enzyme action does not manifest itself as a change in knot type, or the knots types are not 'standard', these knot theoretic models are less germane.

Here we give a taxonomy of local DNA axis configurations. We endow this classification with a distance: that determines how many enzyme reactions of a particular type (corresponding to steps of a specified size) are needed to proceed from one local conformation to another. We discuss a variety of applications of this categorization, including type-II topoisomerase, site-specific recombinase, and transposase-mediated reactions. (Received September 15, 2010)

1067-57-924 **Dave Auckly*** (auckly@msri.org), 17 Gauss Way, Berkeley, CA 94720. *Two-fold branched covers.*

It is possible to give a census of 2-fold covering behavior for surgeries on knots of 10 or fewer crossings. There are integral homology spheres that are not 2-fold branched covers of any 3-manifold, there are examples that are 2-fold branched covers of S^3 but no other manifold, examples that cover some manifold but not S^3, and examples that cover several different manifolds. This talk will present these examples. Thurston asked if any every closed, irreducible, atoroidal 3-manifold with infinite fundamental group has a finite cover which is a surface bundle over the circle. This is the virtual fibering conjecture. The presentation will also include a virtual virtual fibering result showing that the answer is yes if cover is replaced by branched cover. (Received September 16, 2010)

1067-57-933 **Kashyap Rajeevsarathy*** (kashyap@math.ou.edu), Department of Mathematics, 601 Elm Ave, PHSC 423, Norman, OK 73019. *Fractional powers of Dehn twists.*

Let t_C be a Dehn twist about a nonseparating curve C in a surface G of genus $g+1$. A *fractional power* of t_C of *exponent* $\ell//n$ is a homeomorphism h such that h^n is isotopic to t_C^ℓ, that is, $[h]^n = [t_C]^\ell$ in the mapping class group of G. In particular, a root of t_C of degree n is just a fractional power of exponent $1//n$. A fractional power is *side-exchanging* (SE) if it interchanges the two sides of C, and *side-preserving* (SP) otherwise. As the main result, we state necessary and sufficient conditions for the existence of an SE or SP fractional power of t_C of degree $\ell//n$. We will also state some applications of the main result in both cases. (Received September 16, 2010)

1067-57-1097 **Jeffrey J Rolland*** (rollandj@uwm.edu), University of Wisconsin - Milwaukee, Department of Mathematical Sciences, PO Box 413, Milwaukee, WI 53201-0413. *A Geometric Reverse to Quillen's Plus Construction.*

Quillen's Plus Construction is a way of taking a closed manifold M^n ($n \geq 5$) whose fundamental group $G = \pi_1(M)$ contains a perfect normal subgroup P and forming a cobordism (W, M, M^+) to a manifold M^+ with $\pi_1(M^+) \cong Q = G/P$.

We outline a reverse to this procedure, that is, taking a closed manifold N with $\pi_1(N) = Q$ and forming a cobordism (V, N, N_-) to a manifold N_- with $G = \pi_1(N_-)$ a group extension of Q by a prescribed super-perfect group S, that is, with G satisfying a short exact sequence $1 \to S \to G \to Q \to 1$. (Received September 18, 2010)

1067-57-1146 **John Etnyre*** (etnyre@math.gatech.edu), School of Mathematics, 686 Cherry Street, Georgia Institute of Technology, Atlanta, GA 30332, and **Rafal Komendarczyk** and **Patrick Massot**. *Tightness in contact metric manifolds.*

Since the work of Chern and Hamilton there has been a great deal of work on studying Riemannian metrics adapted to contact structures, but most of this work has focused on properties of the Riemannian metric. There have been few results concerning properties of the contact structure in terms of the Riemannian metric. In this talk I will discuss a version of "Darboux's theorem with estimates". More precisely I will give estimates on the size of a geodesic ball in a contact metric manifold that is contactomorphic to the standard contact 3-ball. This is one of the first results relating the key contact geometric notion of tightness to adapted Riemannian metrics. This is joint work with Rafal Komendarczyk and Patrick Massot. (Received September 19, 2010)

1067-57-1176 **Zhenyi Liu*** (zhenyi.liu@okstate.edu), 300 S. Roselle Rd. , #207, Schaumburg, IL 60193. *Classification of One-sided Incompressible Surfaces in Two Infinite Families of Seifert Fibered Spaces.*

In this paper, we identify all one-sided incompressible surfaces, up to isotopy, in the generalized quaternion spaces S^3/Q_{4k}, which are Seifert fibered spaces $M_k = (S^2 : (2,1),(2,1),(k,-k+1))$, $k \geq 2$. The techniques used can be expanded to give the classification of one-sided incompressible surfaces in the minimal layered chain pair triangulations of Seifert fibered spaces $(S^2 : (2,-1),(r+1,1),(s+1,1))$, $r,s \geq 1$. (Received September 19, 2010)

1067-57-1234 **Yuanan Diao*** (ydiao@uncc.edu), Department of Mathematics and Statistics, UNCC, Charlotte, NC 28223. *The variance of the writhe of equilateral random polygons.* Preliminary report.

The variance of the writhe of an equilateral random polygon is a problem that has not been studied in depth before. In this talk, I will discuss the formulation of this problem and the technical difficulties in obtaining a precise formula for it. I will present some partial analytic results that suggest the variance should behave as $O(n \ln n)$. Some numerical results will be presented that supports this conjecture. (Received September 20, 2010)

1067-57-1256 **Elizabeth Denne*** (edenne@smith.edu), Department of Mathematics & Statistics, Smith College, Northampton, MA 01063, and **John M Sullivan** and **Nancy C Wrinkle**. *Flat Ribbon Links in* $\mathbb{R}^2$. Preliminary report.

Knots and links are modeled as flat ribbons immersed in $\mathbb{R}^2$ without folding. This is a 2-dimensional analogue of thick knots and the new work grew out of the theory of ropelength criticality studies by the second and third authors (and others). This talk will give an update of this joint work in-progress. In particular, it will give examples of flat ribbon links, definitions and a discussion of the technicalities involved - that moving from 3 to 2 dimensions does not necessarily simplify the mathematics involved. (Received September 20, 2010)

1067-57-1275 **Matt Rathbun*** (mrathbun@math.msu.edu), A320 Wells Hall, Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Tunnel One, Fibered Links.*

All fibered links can be constructed from the unknot by a sequence of operations called plumbing (and then de-plumbing) Hopf bands. Interestingly, if a fibered link has an unknotting tunnel that happens to lie in the fiber, then plumbing a Hopf band along the tunnel results in a new fibered link that is again tunnel number one. Natural questions are whether this restricted plumbing can always be performed, and whether this is sufficient to construct all tunnel one, fibered links. I will answer the first question affirmatively, and discuss progress towards answering the second. (Received September 20, 2010)

1067-57-1497 **Michael B. Henry*** (mbhenry@math.utexas.edu), Department of Mathematics, The University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712. *Connections between Floer-type invariants and Morse-type invariants of Legendrian knots.*

We define an algebraic/combinatorial object on the front projection Σ of a Legendrian knot called a Morse complex sequence, abbreviated MCS. This object is motivated by the theory of generating families and provides new connections between generating families, normal rulings, and augmentations of the Chekanov-Eliashberg DGA. In particular, after placing an equivalence relation on the set of MCSs on Σ we describe a surjective map from the equivalence classes to the set of chain homotopy classes of augmentations of L_Σ, where L_Σ is the Ng resolution of Σ. In the case of Legendrian knot classes admitting representatives with two-bridge front projections, this map is bijective. We also exhibit two standard forms for MCSs and describe their usefulness. The definition of an MCS and the equivalence relation originate from unpublished work of Petya Pushkar. (Received September 21, 2010)

1067-57-1502 **Clayton Shonkwiler*** (cshonkwi@haverford.edu), Department of Mathematics, Haverford College, 370 Lancaster Ave., Haverford, PA 19041, and **Dennis DeTurck**, **Herman Gluck**, **Rafal Komendarczyk**, **Paul Melvin** and **David Shea Vela-Vick**. *The Search for Higher Helicities.*

Helicity was introduced in 1958 by Woltjer, who showed that the helicity of a magnetic field remains constant as the field evolves according to the equations of ideal magnetohydrodynamics and that it provides a lower bound for the field energy during such evolution. In fact, helicity is the only known topological invariant of vector fields. Arnol′d suggested that there should be higher helicities which provide lower bounds on the field energy when the first helicity vanishes. The integral which computes helicity is analogous to Gauss's famous integral formula for the linking number, suggesting that geometric integral formulas for higher-order linking invariants may lead to higher helicities. I will present such an integral formula for Milnor's triple linking number, which was discovered by proving a correspondence between the link-homotopy invariants of three-component links and the homotopy invariants of associated maps to a configuration space. This correspondence is of independent interest, as it establishes the $n = 3$ case of a conjecture of Koschorke. (Received September 21, 2010)

1067-57-1530 **Joel Louwsma*** (louwsma@caltech.edu), Department of Mathematics 253-37, California Institute of Technology, Pasadena, CA 91125. *Extremality of the rotation quasimorphism on the modular group.* Preliminary report.

It follows from work of Bavard that $\mathrm{scl}(A) \geq \mathrm{rot}(A)/2$ for any element A of the modular group $\mathrm{PSL}(2, \mathbb{Z})$, where scl denotes *stable commutator length* and rot denotes the *rotation quasimorphism*. Sometimes this bound is sharp, and sometimes it is not. We study which elements $A \in \mathrm{PSL}(2, \mathbb{Z})$ have the property that $\mathrm{scl}(A) = \mathrm{rot}(A)/2$. First we describe some experimental results based on computation of stable commutator length. Then we discuss the following stability theorem: for any element of the modular group, the product of this element with a sufficiently large power of a parabolic element satisfies scl = rot/2. This is joint work with Danny Calegari. (Received September 21, 2010)

1067-57-1589 **Louis H. Kauffman*** (kauffman@uic.edu), Mathematics Department, University of Iliniois at Chicacgo, 851 South Morgan Street, Chicago, IL 60607-7045. *Virtual Knots, Khovanov Homology and Quantum Information.*

This talk will review relationships among virtual knot theory, Khovanov homology for classical and virtual knots, and quantum information theory. In particular, we configure a finite dimensional Hilbert space whose basis states generate the Khovanov complex for a knot. In this way we associate a Hilbert space to the knot in such a way that the Khovanov homology appears naturally and so that quantum algorithms for the associated knot polynomial can be interpreted in terms of this homology. This is part of an exploration of the possible physical interpretations of Khovanov Homology, quantum knots and virtual knot theory. (Received September 21, 2010)

1067-57-1825 **Radmila Sazdanovic*** (radmilas@sas.upenn.edu), University of Pennsylvania, Department of Mathematics, David Rittenhouse Lab. 209 South 33rd Street, Philadelphia, PA 19104-6395. *Categorification in knot and graph theory.*

We give an overview of homology theories for links and graphs categorifying various polynomial invariants, and analyze relations between them. (Received September 21, 2010)

1067-57-1994 **Eamonn Tweedy*** (eptweedy@math.ucla.edu). *On the $\mathcal{R}$-filtration for the Heegaard Floer chain complex of a branched double-cover.*

Seidel and Smith defined a knot invariant called symplectic Khovanov homology using braid closures. One can relate a set of generators for their complex to one for the Heegaard Floer hat-complex for the branched double-cover, and the Seidel-Smith homological grading induces a filtration $\mathcal{R}$ on the Heegaard Floer complex. The $\mathcal{R}$-filtered chain homotopy type of this complex is a knot invariant, and tensors under taking connected sums of knots. The filtered complex provides a spectral sequence computing Heegaard Floer hat-homology group, and one obtains an absolute Maslov grading on this group when the spectral sequence collapses at the E_2-page (which occurs for all two-bridge knots, for example). We conclude with some speculation regarding the nature of this filtration. (Received September 22, 2010)

1067-57-2065 **Jason H Cantarella*** (jason@math.uga.edu), UGA Math Department, Boyd GSRC, Athens, GA 30602, and **Jason Parsley**. *Helicity and Energy Bounds For Vector Fields.*

We present new results on computing the helicity of vector fields on domains in $\mathbf{R}^3$ and using the results to derive energy bounds for those fields. (Received September 23, 2010)

1067-57-2073 **Dan Rutherford*** (rutherd@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708-0320. *HOMFLY-PT polynomial and Legendrian links in the solid torus.*

A smooth knot in a contact 3-manifold is called Legendrian if it is always tangent to the contact planes. In this talk, I will discuss Legendrian knots in $\mathbb{R}^3$ and the solid torus where knots can be conveniently viewed using their 'front projections'. In particular, I will describe how certain decompositions of front projections known as 'normal rulings' (introduced by Fuchs and Chekanov-Pushkar) can be used to give combinatorial descriptions for parts of the HOMFLY-PT and Kauffman polynomials. I will conclude by discussing recent generalizations to Legendrian solid torus links. It is usual to identify the 'HOMFLY-PT skein module' of the solid torus with the ring of symmetric functions. In this context, normal rulings can be used to give a knot theory description of the standard scalar product determined by taking the Schur functions to form an orthonormal basis. (Received September 22, 2010)

1067-57-2205 **Alexander Zupan*** (alexander-zupan@uiowa.edu), 15 MacLean Hall, Department of Mathematics, The University of Iowa, Iowa City, IA 52242-1419. *A troublesome embedding of the unknot.*

In 1934, Goeritz exhibited a nontrivial diagram of the unknot that such any sequence of Reidemeister moves converting this diagram to the zero crossing diagram increases the number of crossings of the diagram. As an analogue, we produce a nontrivial embedding of the unknot such that any isotopy from this embedding to the thin position of the unknot increases knot width in the sense of Gabai. This resolves a question of Scharlemann, and we apply our result to demonstrate that the width complexes for knots developed by Schultens have infinitely many local minima that are not global minima. (Received September 22, 2010)

1067-57-2234 **M Kate Kearney*** (mkkearne@indiana.edu), 203 E 8th St, Apt 1, Bloomington, IN 47408. *Concordance Genus of Knots.*

I will discuss examples of calculations of the concordance genus of knots. In particular, I will show a general computation for the concordance genus of sums of torus knots. I will use this to illustrate the significance of the concordance genus and its relationship to the three genus and four genus of knots. (Received September 22, 2010)

1067-57-2260 **Jason Cantarella** and **Jason Parsley*** (parslerj@wfu.edu). *New perspectives on helicity.*

We realize helicity as an integral over the configuration space of 2 points on a domain in Euclidean space. We extend this framework to define submanifold helicities: differential $(k+1)$-forms on n-dimensional subdomains of R^m. This topological approach also produces a general formula for how much helicity changes when the form is pushed forward by a diffeomorphism of the domain. We classify the helicity-preserving diffeomorphisms on a given domain, finding new ones on the two-holed solid torus and proving that there are no new ones on the standard solid torus. (Received September 22, 2010)

1067-57-2406 **Ulrike Tillmann*** (tillmann@maths.ox.ac.uk), Mathematical Institute, 24-29 St Giles, Oxford, OX1 3LB, England. *Spaces of graphs and surfaces - On the work of Soren Galatius.*

Graphs and surfaces are relatively simple, fundamental geometric objects. It is natural to study these in continuous families (or bundles). Only in the last decade we have started to understand these in terms of characteristic classes as we have understood vector spaces since the work of Chern, Pontryagin and Whitney.

One of Soren Galatius' remarkable results is a computation of the (stable) characteristic classes of graph bundles. In more precise and algebraic terms, he shows that the natural action of the symmetric group on the generators of the free group which defines an inclusion $\Sigma_n \to Aut(F_n)$ induces an isomorphism in cohomology in degrees smaller than $(n-1)/2$. In particular, there is no rational cohomology in these degrees.

The ideas and methods that went into his paper grew out of a proof of the Mumford conjecture, now Madsen-Weiss theorem. The latter determines the (stable) characteristic classes of surface bundles. Vice versa, the new methods developed for the case of graphs has led to a simplified approach to the Mumford conjecture and many generalisations of it.
(Received September 23, 2010)

58 ► Global analysis, analysis on manifolds

1067-58-241 **Celso Melchiades Doria*** (cmdoria@mtm.ufsc.br), UFSC, Departamento de Matemática, Campus Universitário, Trindade, Florianopolis - SC, 88034-510, Brazil. *An equivalent condition to the existence of an irreducible Seiberg-Witten Monopole on a smooth closed 4-manifold.*

Let (X,g) be a closed, smooth riemannian 4-manifold. For any fixed spin^c structures α on X, the Seiberg-Witten functional admits two classes of critical points (i) irreducibles: (A,ϕ), $\phi\neq 0$, (ii) reducibles: $(A,0)$. The question addressed concern the existence of irreducible critical points. For this purposes, the Morse-Bott index of the reducible solutions is investigated and it tuns out to be finite after a perturbation on the equations. The

Kronheimer-Mrowka Blow-up procedure is also applied and interesting aspect relating the critical points to the spectrum of the spin^c Dirac operator is obtained. (Received August 21, 2010)

1067-58-487 **Ana Maria Matei*** (amatei@loyno.edu), Loyola University New Orleans, Department of Mathematics, 6363 St Charles Ave, New Orleans, LA 70118. *On the optimality of two isoperimetrical inequalities for the p-Laplacian.*

We study the relationship between the first eigenvalue of the p -Laplacian (p>1) and Cheeger's isoperimetrical constant for families of manifolds and graphs with the Cheeger constant converging to zero. (Received September 06, 2010)

1067-58-558 **Jeehyeon Seo*** (seo6@illinois.edu), 1409 W. Green Street, Urbana, IL 61801. *Bi-Lipschitz embeddability of the Grushin plane into Euclidean space.*

Many sub-Riemannian manifolds like the Heisenberg group do not admit bi-Lipschitz embedding into any Euclidean space. In contrast, the Grushin plane admits a bi-Lipschitz embedding into some Euclidean space. This is done by extending a bi-Lipschitz embedding of the singular line, using a Whitney decomposition of its complement. (Received September 09, 2010)

1067-58-660 **Masha Gordina*** (maria.gordina@uconn.edu), Department of Mathematics, Storrs, CT 06269. *Heat kernel analysis on infinite-dimensional curved spaces.*

The heat kernel analysis has long been an essential tool in diverse areas of mathematics such as analysis, geometry, and probability, as well as in physics. We will review recent developments of the subject in the case of infinite-dimensional curved spaces. (Received September 13, 2010)

1067-58-673 **Nelia Charalambous*** (nelia.ch@gmail.com), Departamento de Matematicas, ITAM, Rio Hondo #1, Col. Tizapan-San Angel, 01000 Mexico, DF, Mexico. *The space of harmonic sections on noncompact manifolds.*

The space of harmonic functions and forms over a compact manifold is determined by the topology of the manifold. Over noncompact manifolds however, these spaces reflect not only the topology, but also the geometry of the manifold including its curvature and volume growth. In this talk we will discuss the space of harmonic functions of polynomial growth and will present sufficient conditions on the manifold so that its dimension is bounded. We will also see how to generalize these results to the space of harmonic forms. (Received September 13, 2010)

1067-58-953 **Corbett Redden*** (redden@math.msu.edu), A-318 Wells Hall, Department of Mathematics, Michigan State University, East Lansing, MI 48824. *String structures and loop spaces.* Preliminary report.

A string structure on a principal $Spin(k)$-bundle P is a lift of the structure group to $String(k)$, a group which is a 3-connected cover of $Spin(k)$. A string structure on P give rise to a "spin structure" on the free loop bundle LP; it lifts the structure group of LP to the universal central extension of $LSpin(k)$.

In this talk we analyze a concrete model of $String(k)$ and explicitly show how string structures on P transgress to desired structures on LP. We also note the relationship between various definitions of string structures and the advantages of working on P as opposed to LP. (Received September 16, 2010)

1067-58-1088 **K. D. Elworthy*** (kde@maths.warwick.ac.uk), Maths Institute, Warwick University, Coventry, CV4 7AL, England. *Vanishing of L^2 harmonic one-forms on based path spaces of Riemannian manifolds.*

Following Len Gross's work on abstract Wiener spaces and their potential theory in the late 1960's the natural calculus for analysis on path spaces with diffusion measures has been based on differentiation in the directions of so-called "Bismut tangent spaces" . Malliavin calculus type techniques were extended to this situation through work of Gross's ex-student Bruce Driver in the 1990's, to give a theory of Sobolev spaces and scalar potential theory. In general the "Bismut tangent bundle" is not integrable leading to difficulties in setting up a Hodge Laplacian for L^2 forms. An approach to this was suggested by the author and Xue-Mei Li, with a detailed treatment for one-forms in 2008. Recently, work by the author with his student Yuxin Yang has provided a proof of vanishing of first L^2 cohomology groups in this context, with corresponding vanishing of L^2 harmonic one-forms. This proof will be described, demonstrating a pleasing interplay between the differential geometry of the Bismut tangent spaces and the temporal structure of the underlying path space. The proof, together with the unsurprising vanishing, might be considered to justify the definition of exterior derivative proposed in the earlier work with Xue-Mei Li. (Received September 18, 2010)

1067-58-1113 **E Cabral Balreira*** (ebalreir@trinity.edu), One Trinity Place, Department of Mathematics, San Antonio, TX 78212. *A Generalization of the Fujisawa-Kuh Global Inversion Theorem.* Preliminary report.

We discuss the global invertibility of nonlinear maps defined on the finite dimensional Euclidean space via differential tests and provide a generalization of the Fujisawa-Kuh Global Inversion Theorem. We also introduce a generalized ratio condition to establish when the pre-image of a certain class of linear manifolds is non-empty and connected. In particular, we provide conditions to detect global injectivity. (Received September 19, 2010)

1067-58-1284 **Luen-Chau Li*** (luenli@math.psu.edu), Department of Mathematics, Pennsylvania State University, University Park, PA 16802, and **Zhaohu Nie** (znie@psu.edu), Department of Mathematics, Pennsylvania State University, Altoona Campus, 3000 Ivyside Park, Altoona, PA 16601. *Liouville integrability of a class of integrable spin Calogero-Moser systems and exponents of simple Lie algebras.*

In previous work, we introduced a class of integrable spin Calogero-Moser systems associated with the classical dynamical r-matrices with spectral parameter, as classified by Etingof and Varchenko for simple Lie algebras. In this talk, we will show how to establish Liouville integrability of these systems by a uniform method. In principle, the method which we develop here to construct and count the number of integrals should also work for other systems associated with simple Lie algebras and with spectral parameter dependent Lax operators. (Received September 20, 2010)

1067-58-1331 **Gerard Misiolek***, Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Euler-Arnold equations on orbits of diffeomorphism groups.*

I will describe geodesic equations of right-invariant metrics on certain orbits of diffeomorphism group in spaces of Riemannian metrics and volume forms. (Received September 20, 2010)

1067-58-1425 **Nathaniel Eldredge*** (neldredge@math.cornell.edu), 593 Malott Hall, Cornell University, Ithaca, NY 14850. *Hypoelliptic heat kernel inequalities on H-type groups.*

We discuss heat kernel inequalities for the hypoelliptic sub-Laplacian on H-type nilpotent Lie groups, together with consequences such as Gross's logarithmic Sobolev inequality, and possible infinite-dimensional generalizations. (Received September 21, 2010)

1067-58-1518 **B. Ntatin*** (ntatinb@apsu.edu), Department of Mathematics, Austin Peay State University, Clarksville, TN 37044. *Definition of the Cycle Space of Orbits of Semi-simple Lie Groups acting on Flag Manifolds.*

Actions of Lie groups on manifolds normally give rise to induced actions on the parameter spaces of certain geometric objects related to the manifolds in question. For instance, from the canonical representation of $SL_n(\mathbb{R})$ on $\mathbb{C}^n$, one obtains actions on the parameter spaces of linear subspaces of $\mathbb{C}^n$, that is, Grassmannians $\mathbb{G}r_k(\mathbb{C}^n)$ of k-dimensional subspaces of $\mathbb{C}^n$, flag manifolds $\mathbb{F}_{1,2,\ldots,k}(\mathbb{C}^n)$ and so on. These in turn give rise to new representations on associated spaces of functions, sections of line bundles, differential forms among others. In this talk we will give a definition of the parameter space of certain nonlinear geometric objects (cycles) in the natural setting of group action. Although the objects considered are quite concrete, and the ideas could be generalized, we will only consider low-dimensional examples. (Received September 21, 2010)

60 ► Probability theory and stochastic processes

1067-60-2 **George C Papanicolaou*** (papanico@math.stanford.edu), Department of Mathematics, Stanford University, Stanford, CA 94305. *Mathematical problems in systemic risk.*

The quantification of uncertainty in complex systems depends on the individual uncertainty of their components, the connectivity of the system and on the way uncertainty evolves over time. Quantifying systemic risk for a complex system means identifying regimes in which small changes in individual components can cause catastrophic failure of the whole system. How can we characterize mathematically such regimes of fragility that may remain hidden and difficult to detect? I will address the mathematical modeling of systemic risk in complex systems and give examples from finance (banking, credit cards), power systems, ecological systems, complex engineering systems, etc., and discuss some old and some new mathematical methods for dealing with these issues. (Received September 19, 2010)

1067-60-10 **Scott R. Sheffield*** (sheffield@math.mit.edu), 77 Mass. Ave., Cambridge, MA 02139-4307. *Conformal weldings in quantum gravity: zippers, necklaces, and SLE.*

- Liouville quantum gravity is a canonical notion of a random two-dimensional surface. It was originally proposed as a model for the intrinsic Riemannian geometry on the space-time trajectory of a string.
- The Schramm-Loewner evolution (SLE) is a canonical notion of a random non-self-crossing path in the plane. It appears frequently in two-dimensional statistical physics and conformal field theory.

It turns out that SLE is the right tool for understanding how to combine and subdivide the random geometries of Liouville quantum gravity. When we "glue" or "conformally weld" independent random surfaces to each other, the interfaces between the surfaces become forms of SLE. These findings are consistent with the (still unproven) belief that Liouville quantum gravity is a scaling limit of discrete random surfaces. (Received September 22, 2010)

1067-60-136 **Jonathon Peterson*** (peterson@math.cornell.edu), Cornell University, Mathematics Department, Malott Hall, Ithaca, NY 14853, and **Nina Gantert**, Institute of Mathematical Statistics, Einsteinstrasse 62, 48149 Munster, Germany. *Bridges of random walks in a random environment.*

A bridge of a random walk is a path of length $2n$ that begins and ends at the origin. It is well known that the bridge of a simple random walk, when scaled by $\sqrt{n}$, converges in distribution to a Brownian bridge. In particular, this implies that the maximal displacement of the bridge is of the order $\sqrt{n}$.

We are interested in studying the distribution of bridges for transient one-dimensional random walks in a random environment. It turns out that in this case the maximal displacement of bridges is of the order $n^{\kappa/(\kappa+1)}$, where $\kappa > 0$ depends on the distribution on environments. The distribution on environments can be chosen to obtain any value $\kappa > 0$. In this talk I will explain how this result is obtained by using what is called the "potential" of the environment to study the trapping effects of the environment.

This is based on joint work with Nina Gantert. (Received July 27, 2010)

1067-60-295 **Leila Setayeshgar*** (leila@fritz.dam.brown.edu), Division of Applied Mathematics, Brown University, 182 George St. Box F, Providence, RI 02912, and **Hui Wang** (huiwang@cfm.brown.edu), Division of Applied Mathematics, Brown University, 182 George St. Box F, Providence, RI 02912. *Large Deviations and Importance Sampling for a Feedforward Network.*

We consider a feedforward network with a preemptive service discipline, serving jobs with multiple levels of priority. In the special case where jobs have two different priority levels, we use tools from the theory of large deviations to explicitly identify the exponential decay rate of the total population overflow probabilities. We then construct asymptotically optimal importance sampling schemes to estimate the exact probability of interest. (Received August 17, 2010)

1067-60-339 **Erik Lewis*** (elewis@math.ucla.edu), **George Mohler**, **P. Jeffrey Brantingham** and **Andrea Bertozzi**. *Self-Exciting Point Process Models of Civilian Deaths in Iraq.*

Our goal in this paper is to analyze temporal patterns of civilian death reports in Iraq. For this purpose we employ a branching point process model similar to those used in earthquake analysis. Here the rate of events is partitioned into the sum of a Poisson background rate and a self-exciting component in which events trigger an increase in the rate of the process. More specifically, each event generated by the process in turn generates a sequence of offspring events according to a Poisson distribution. Whereas the background rate is typically assumed to be stationary for seismic activity, such an assumption is not valid in the context of civilian deaths in Iraq. We propose three simple adjustments to account for background rate variation and compare the effectiveness of each model using Iraq Body Count data from 2003 to 2007. Our results indicate that branching point processes are well suited for modeling the temporal dynamics of violence in Iraq. (Received August 24, 2010)

1067-60-360 **Mark A McKibben*** (mmckibben@goucher.edu), Goucher College, 122 Hoffberger Science Building, 1021 Dulaney Valley Road, Baltimore, MD 21204. *On a class of abstract measure-dependent stochastic evolution equations.* Preliminary report.

The talk will focus on a discussion of existence, convergence, and approximation results for a class of abstract parameter-dependent stochastic evolution equations under general growth conditions. Commentary on impulsive and delay versions of this class of equations will also be included. Several applications of the theory to specific initial-boundary value problems will be provided as both motivation and illustration of the abstract theory presented. (Received August 27, 2010)

1067-60-394 **Zhuo Jin*** (zjin@math.wayne.edu), 656 W.Kirby, 1150 FAB, Department of Mathematics, Wayne State University, Detroit, MI 48202. *Numerical Methods for Annuity-Purchasing Decision Making.*

This work develops approximation methods to obtain the optimal annuity-purchasing strategies to minimize the probability that a fixed consumption level lead to zero wealth while the individual is still alive. A regime-switching diffusion model is considered, which includes both continuous dynamics and discrete events modulated by a finite-state Markov chain. The solution can be represented by a system of Hamilton-Jacobi-Bellman (HJB) equations. By using Markov chain approximation method, a discrete-time controlled Markov chain with two component is constructed. The convergence of approximation sequence to the wealth process and value function is established. At last, several examples are provided to illustrate the performance of the algorithms. (Received September 01, 2010)

1067-60-409 **Qingshuo Song** (song.qingshuo@cityu.edu.hk), Department of Mathematics, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon Tong, Hong Kong, Hong Kong, **Richard Stockbridge** (stockbri@uwm.edu), Department of Mathematical Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI 53201, and **Chao Zhu*** (zhu@uwm.edu), Department of Mathematical Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI 53201. *On Optimal Harvesting Problems in Random Environments.*

This work investigates the optimal harvesting strategy for a single species living in random environments whose growth is given by a switching diffusion. Harvesting acts as a stochastic control on the population size. The objective is to find a harvesting strategy which maximizes the expected total discounted income from harvesting up to the time of extinction of the species. This is a singular stochastic control problem, with both the extinction time and harvesting policy depending on the initial condition. Consequently one no longer obtains continuity of the value function using the standard arguments. We provide a sufficient condition for the continuity of the value function. Further, we characterize the value function as a viscosity solution of a coupled system of quasi-variational inequalities. We also establish a verification theorem. Based upon the verification theorem, an ϵ-optimal harvesting strategy is constructed and two examples are analyzed in detail. The novelties of this work include the modeling of abrupt changes in the random environments and the state- and regime-dependent marginal yield function. While these considerations enable a better approximation of the real world dynamics, they add considerable difficulty to the analysis. (Received September 01, 2010)

1067-60-410 **Kunwoo Kim*** (kkim27@illinois.edu), **Richard B. Sowers** and **Zhi Zheng**, Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green st., Urbana, IL 61801. *A Stochastic Stefan Problem.*

The classical Stefan problem describes phase change phenomena in solid-liquid systems. In this talk, we consider the one-dimensional Stefan problem perturbed by noise which is spatially correlated but white in time. We see how the noise affects to the system and show the existence and uniqueness of solutions. (Received September 20, 2010)

1067-60-467 **Min Kang*** (kang@math.ncsu.edu), Department of Mathematics, NC State University, Raleigh, NC 27695. *Immortal Particle for a Catalytic Branching Process.*

We study the existence and asymptotic properties of a conservative branching particle system driven by a diffusion with smooth coefficients for which birth and death are triggered by contact with a set. Sufficient conditions for the process to be non-explosive are given in relation to the eikonal equation. In the Brownian motions case the domain of evolution can be non-smooth, including Lipschitz, with integrable Martin kernel. The results are valid for an arbitrary number of particles and non-uniform redistribution after jump. Additionally, with probability one, it is shown that only one ancestry line survives. In special cases, the evolution of the surviving particle is studied and for a two particle system on a half line we derive explicitly the transition function of a chain representing the position at successive branching times. (Received September 05, 2010)

1067-60-468 **Peter Olofsson*** (polofsso@trinity.edu), Mathematics Department, Trinity University, One Trinity Place, San Antonio, TX 78212, and **Ryan C Daileda**, Mathematics Department, Trinity University, One Trinity Place, San Antonio, TX 78212. *Budding yeast, branching processes, and generalized Fibonacci numbers.*

We present an application of branching processes to a problem in cell biology where the generalized Fibonacci numbers known as k-nacci numbers play a crucial role. The k-nacci sequence is used to obtain computational formulas, establish asymptotic growth rate, and to justify certain practical simplifications in a branching process application in cell biology. (Received September 05, 2010)

1067-60-469 **Peter Olofsson** (polofsso@trinity.edu), Mathematics Department, Trinity University, One Trinity Place, San Antonio, TX 78212, and **Xin Ma*** (xma@trinity.edu), Mathematics Department, Trinity University, One Trinity Place, San Antonio, TX 78212. *Estimating bacterial lag phase: a branching process approach.*

Before a population of bacteria (or other cells) starts growing exponentially, there may also be an initial phase, the lag phase, when the bacterium adjusts to a new environment. Accurate estimation of the lag phase is important in the field of predictive food microbiology. We propose a branching process model for the cell population and demonstrate how this approach leads to improved estimates of the lag phase. (Received September 05, 2010)

1067-60-502 **Tien Nguyen Dung*** (dungnt@math.wayne.edu), Department of Mathematics, 1118 Faculty/Administration Building, 656 W. Kirby, Detroit, MI 48202, and **George Yin** (gyin@math.wayne.edu), Department of Mathematics, 1217 Faculty/Administration Building, 656 W. Kirby, Detroit, MI 48202. *Systems of Kolmogorov Backward Equations for Two-Time-Scale Switching Diffusions.*

We consider solutions of systems of backward equations for continuous-time Markov processes. In the model, the systems display both diffusive and switching behavior featuring in the coexistence of continuous dynamics and discrete events. Unlike the usual consideration of Markovian regime-switching systems, the generator of the switching component depends on the continuous state. Fast switching systems and fast diffusion systems are treated by using the two-time-scale formulation. Under appropriate conditions such as boundedness and smoothness, asymptotic expansions are developed for the solutions of the systems of backward equations. (Received September 07, 2010)

1067-60-582 **Tankut Dogrul***, 415 EMCS Building, Department 6956, 615 McCallie Ave, Chattanooga, TN 37403. *A Nash Equilibrium with several large traders.* Preliminary report.

Motivated by the problem of pricing financial assets in incomplete markets due to the presence of price impact, an equilibrium model with a representative market maker and a finite number of large traders is considered. Prices for (illiquid) European contingent claims with payoffs at maturity as well as optimal trading strategies for the large traders are characterized as a result of various equilibrium concepts such as Nash, subgame perfect Nash and Arrow-Debreu. Using techniques from optimal control theory, equilibrium final wealth allocations are characterized by a finite set of non-linear equations. Dynamic trading strategies in continuous time trading are then obtained by martingale representation results. (Received September 10, 2010)

1067-60-585 **Sheng Xiong*** (sheng@temple.edu), Math Department, Temple university, 1805 N Broad St., Philadelphia, PA 19122, and **Wei-Shih Yang** (yang@temple.edu), Math Department, Temple University, 1805 N Broad St., Philadelphia, PA 19122. *Ruin probability in the Cramér-Lundberg model with risky investments.* Preliminary report.

We consider the Cramér-Lundberg model with investments in an asset with large volatility, where the premium rate is a bounded nonnegative random function c_t and the price of the invested risk asset follows a geometric Brownian motion with drift a and volatility $\sigma > 0$. It is proved by Pergamenshchikov and Zeitouny that the probability of ruin, $\psi(u)$, is equal to 1, for any initial endowment $u \geq 0$, if $\rho := 2a/\sigma^2 \leq 1$ and the distribution of claim size has an unbounded support. In this paper, we prove that $\psi(u) = 1$ if $\rho \leq 1$ without any assumption on the positive claim size.
(Received September 10, 2010)

1067-60-624 **Meng Xu*** (mxu@uwyo.edu), 2601 Coe Street, Apt 392, Laramie, WY 82072, and **Sritharan** (sssritha@nps.edu). *A Stochastic Lagrangian Particle Model and Nonlinear Filtering for Three Dimensional Euler Flow with Jumps.*

In this paper we will introduce a stochastic Lagrangian particle model with jumps for the three dimensional Euler ow and study the associated nonlinear filtering problem.We apply results from backward integro-differential equation problem to prove uniqueness of solution to the Zakai equations. (Received September 12, 2010)

1067-60-717 **Elife Dogan*** (elife.dogan@ttu.edu), Mathematics & Statistics, Texas Tech University, Lubbock, TX 79410, and **Edward J. Allen** (edward.allen@ttu.edu). *Derivation Of Stochastic Partial Differential Equations for Reaction-Diffusion Processes.*

Stochastic partial differential equations are derived for the reaction-diffusion process in one, two and three dimensions. Specifically, stochastic partial differential equations are derived for the random dynamics of particles that are reacting and diffusing in a medium. In the derivation, a discrete stochastic reaction-diffusion equation

is first constructed from basic principles, i.e., from the changes that occur in a small time interval. As the time interval goes to zero, the discrete stochastic model leads to a system of Ito stochastic differential equation. As the spatial intervals approach zero, a stochastic partial differential equation is derived for the reaction-diffusion process. The stochastic reaction-diffusion equation can be solved computationally using numerical methods for systems of Ito stochastic differential equations. Comparisons between numerical solutions of stochastic reaction-diffusion equations and independently formulated Monte Carlo calculations support the accuracy of the derivations. (Received September 14, 2010)

1067-60-722 **Maria Teresa Giraudo*** (`mariateresa.giraudo@unito.it`), Dept. of Mathematics University of Torino, Via Carlo Alberto 10, 10123 Torino, Italy, and **Laura Sacerdote**, **Roberta Sirovich** and **Cristina Zucca**. *Estimation of information measures in coupled diffusion neuronal models.*

The study of information transmission between neurons plays a relevant role in neuroscience. The interspike times (ISI) are recognized as the random variables coding the information elaborated by a neuron connected to a surrounding network. However many problems are still open for the understanding of the statistical dependence properties of ISI's for neurons in a specific network. Various methods have been proposed in the framework of Information theory. The quantification of the amount of information contained in the activity of two or more connected neurons allows to extract the statistical features of spike trains and to characterize dependencies in their behaviour. Estimation of the mutual information between ISI's may be a useful tool in this framework. We compute here the mutual information of coupled model neurons whose interaction is determined by the firing times. The mutual information between the random variable describing the spiking times of the neurons is estimated employing the copula function describing the dependence between the spiking distributions. This allows to underline how the use of copulae enables to recognize directly the contribution due strictly to the coupling structure subject on the variations in the parameters characterizing the models. (Received September 14, 2010)

1067-60-766 **Jin Ma** and **Hong Yin*** (`hongyin@usc.edu`), Department of Mathematics, University of Southern California, 3620 Vermont Avenue, KAP108, Los Angeles, CA 90089, and **Jianfeng Zhang**. *Equivalence Relationship between Forward Backward SDEs and Backward SPDEs.*

The main purpose of this talk is to establish an equivalence relationship between well-posedness of forward backward SDEs with random coefficients and that of backward stochastic PDEs. For FBSDEs with deterministic coefficients, it is well-known that the backward component of the FBSDEs can be written as a deterministic function of the forward component, and this function is the solution to a PDE in certain weak sense. For general FBSDEs, such function becomes a random field and the corresponding PDE becomes a backward SPDE. We show that, under certain conditions, the FBSDEs is well-posed if and only if this random field is a Sobolev type weak solution to the BSPDE. This result extends the well-known four step scheme to a random coefficients case, and provides a Feynman-Kac type formula for solutions to BSPDEs. As a corollary, we prove the well-posedness and comparison principle for quasilinear BSPDEs, which is also novel in the literature. (Received September 14, 2010)

1067-60-803 **Qiang Zhen*** (`q.zhen@unf.edu`), 1 UNF Drive, Bldg 14/2731, Jacksonville, FL 32256, and **J.S.H. van Leeuwaarden** and **Charles Knessl**. *On a Processor Sharing Queue That Models Balking.*

We consider the processor sharing $M/M/1$-PS queue which also models balking. A customer that arrives and sees n others in the system "balks" (i.e., decides not to enter) with probability $1-b_n$. If b_n is inversely proportional to $n+1$, we obtain explicit expressions for a tagged customer's sojourn time distribution. We consider both the conditional distribution, conditioned on the number of other customers present when the tagged customer arrives, as well as the unconditional distribution. We then evaluate the results in various asymptotic limits. These include large time (tail behavior) and/or large n, lightly loaded systems where the arrival rate $\lambda \to 0$, and heavily loaded systems where $\lambda \to \infty$. We find that the asymptotic structure for the problem with balking is much different from the standard $M/M/1$-PS queue. (Received September 15, 2010)

1067-60-829 **Mehdi Razzaghi*** (`razzaghi@bloomu.edu`), Department of Mathematics, Bloomsburg University, Bloomsburg, PA 17815. *Poisson Approximation of the Poisson Lindley Didtribution.*

The Poisson-Lindley distribution arises from the Poisson model by compounding it with the Lindley distribution and it is used to model count data. The distribution is known to have some common properties with the negative binomial distribution and to provide good approximation to the negative binomial and the Hermite distributions. In this paper we consider the Poisson approximation to the Poisson-Lindley distribution. Using the w-function along with the Stein identity we derive an upper bound for the total variation distance of this approximation. (Received September 15, 2010)

1067-60-849 **Meredith Burr*** (mburr@ric.edu), Dept. of Mathematics and Computer Science, Rhode Island College, 600 Mount Pleasant Avenue, Providence, RI 02908. *Continuous-time random walks, their scaling limits, and connections with stochastic integration.* Preliminary report.

Brownian motion is a well-known model for normal diffusion, but not all phenomena can be modeled by Brownian motion; many exhibit irregular diffusive behavior, called anomalous diffusion. Examples have been observed in physics, hydrology, biology, and finance, among many other fields. Continuous-time random walks (CTRWs), introduced by Montroll and Weiss, serve as models for anomalous diffusion. CTRWs generalize the usual random walk model by allowing random waiting times between successive random jumps. Under certain conditions on the jumps and waiting times, scaled CTRWs can be shown to converge in distribution to a limit process $M(t)$ in the càdlàg space $\mathbb{D}[0,\infty)$ with the Skorohod J_1 or M_1 topology. An interesting question is whether stochastic integrals driven by the scaled CTRWs $X^n(t)$ converge in distribution to a stochastic integral driven by the CTRW limit process $M(t)$? We prove weak convergence of the stochastic integrals driven by CTRWs for certain classes of CTRWs, when the CTRW limit process is an α-stable Lévy motion and when the CTRW limit process is a time-changed Brownian motion. This talk is based on my Ph.D. dissertation, written under the direction of Professor Marjorie Hahn at Tufts University. (Received September 15, 2010)

1067-60-890 **Hui-Hsiung Kuo*** (kuo@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, **Anuwat Sae-Tang** (anuwat@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Benedykt Szozda** (benny@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *A stochastic integral for adapted and instantly independent stochastic processes.*

We study a new stochastic integral for stochastic processes which are generated by adapted and instantly independent stochastic processes. In the definition of the new stochastic integral, the crucial idea of forming Riemann-like sums is the evaluation points for the integrands, namely, the adapted factors are evaluated at the left endpoints of the subintervals, while the instantly independent factors are evaluated at the right endpoints of the subintervals. We will present some results on the existence of this new stochastic integral for an interesting class of stochastic processes. We will also introduce the concept of pre-martingale which is used in studying stochastic processes defined by this new stochastic integral. (Received September 16, 2010)

1067-60-974 **Fariborz Asadian*** (asadianf@fvsu.edu), Department of Mathematics & Computer Science, Fort Valley State University, 1005 State University Drive, Fort Valley, GA 31088. *Differentiability Properties of Measures Generated by Solutions of Semilinear Stochastic Differential Equations.*

We employ the Girsanov Theorem to investigate smoothness properties of the measures generated by the solutions of semilinear stochastic differential equations of the type $d\xi(t) = [A\xi(t) + \sigma(t,\xi(t))]dt + dW(t)$, where $W(t), 0 \leq t \leq T$, is a cylindrical Wiener process in a separable Hilbert space H and A is an infinitesimal generator of a C_0-semigroup of operators on H. The subspaces of differentiability of these measures are characterized and the results are applied to explore the Wiener chaos decompositions of the solutions. (Received September 17, 2010)

1067-60-1000 **Steven E. Shreve*** (shreve@andrew.cmu.edu), Department of Mathematicsal Sciences, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213. *Did Mathematics Cause the Subprime Mortgage Disaster?*

As we find ourselves working through the worst financial crisis since the Great Depression, we cannot help but ask what role mathematics played in this. Over the past twenty-five years the practice of finance has been revolutionized by the widespread adoption of mathematical models for pricing ever more exotic derivative securities. Mortgage-backed securities, which triggered the financial collapse, were priced using the Gaussian copula model, a mathematical construct. Based on the prices produced by this model, trillions of dollars traded hands. This talk reviews the role of mathematics in finance, the assumptions on which mathematical models for finance are built, and the history of use and misuse of these models. (Received September 17, 2010)

1067-60-1006 **Jean-Claude Pedjeu***, Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700, and **Gangaram S Ladde** (gladde@usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *Fractional Differential Equations:Stochastic Modeling, Methods and Analysis.* Preliminary report.

Stochastic models of dynamic processes with long-time behavior are developed. Methods of finding close form solutions are outlined. The process of close form solutions is used to address a few fundamental problems in the theory of stochastic fractional differential equations. We also explore numerical methods for finding the solution of fractional stochastic differential equations. (Received September 17, 2010)

1067-60-1009 **Mang Wu*** (mangwu@math.ucr.edu), Department of Mathematics, University of California, Riverside, 900 University Ave, Riverside, CA 92521. *A Brownian Motion on the Group of Diffeomorphisms of the Circle.*

Let Diff(S1) be the group of orientation preserving infinitely differentiable diffeomorphisms of the circle. The geometry on, and consequently the Brownian motion on the group Diff(S1) has much to do with the metric on Diff(S1). In this talk, we first identify the group Diff(S1) as a subset of a certain function space, and then give it a certain metric, and finally, we construct a Brownian motion that lives in the group Diff(S1). (Received September 17, 2010)

1067-60-1023 **Ling Wu*** (lwu5@mail.usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700, and **Gangaram S Ladde** (gladde@usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *Option Pricing for Hybrid Nonlinear Stochastic Models.* Preliminary report.

We first develop three nonlinear stochastic models with time varying coefficients. Then, we derive the option pricing formula in the context of the proposed three nonlinear stochastic models. The option pricing formula in the frame work of hybrid systems, namely, Hybrid GBM (HGBM) and hybrid nonlinear stochastic models are also presented. The simulation results are given at the end of this presentation. (Received September 17, 2010)

1067-60-1026 **Divine T Wanduku*** (wandukudivine@yahoo.com), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700, and **Gangaram S Ladde** (gladde@usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *Stochastic Stability of Two-scale Network Dynamic Epidemic Model.* Preliminary report.

The non-uniform global spread of emergent infectious diseases of humans is closely interrelated with the large-scale structure of the human population, and the human mobility process in the population structure. The mobile population becomes the vector for the disease. We present an SIRS stochastic dynamic epidemic process in a two scale structured population.The variability caused by the fluctuating environment is assumed to manifest mainly in the transmission process. We investigate the stochastic stability of scale structured mobile population, under environmental fluctuations and its impact on the emergence, propagation and resurgence of the disease. The presented results are demonstrated by numerical simulation results. (Received September 17, 2010)

1067-60-1122 **George C Papanicolaou*** (papanico@math.stanford.edu), Department of Mathematics, Stanford University, Stanford, CA 94305. *Correlation based imaging.*

I will discuss passive array imaging where the echoes recorded are generated by noise sources in the ambient environment. The location of reflectors is done by an image function that uses cross correlations of the recorded signals. I will discuss the resolution of images obtained this way as well as signal to noise ratio issues that can be a limiting factor to the this kind of imaging methods. (Received September 19, 2010)

1067-60-1126 **Yumin Lolita Wang*** (yumin@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University (SUNY), Binghamton, NY 13902, and **Gang George Yin** (gyin@math.wayne.edu), Department of Mathematics, Wayne State University, Detroit, MI 48202. *Quantile Hedging for Guaranteed Minimum Death Benefits with Regime-Switching.* Preliminary report.

Quantile hedging for contingent claims plays a key role in incomplete markets when perfect hedging is not possible. Guaranteed minimum death benefits (GMDBs) are present in many variable annuity contracts, and act as a form of portfolio insurance. They cannot be perfectly hedged due to the mortality component and incompleteness resulting from the regime switching, except in the limit as the number of contracts becomes infinitely large. In this article, quantile hedges for regime-switching diffusion models are developed. Numerical examples are also presented to illustrate our results. (Received September 19, 2010)

1067-60-1161 **Yalcin Sarol***, 8600 University Blvd, Evansville, IN 47712. *Stochastic control for linear systems with fractional Brownian motion.* Preliminary report.

We consider some stochastic control problems for dynamical systems driven by fractional Brownian motion B^H with any Hurst parameter $H \in (0,1)$. The linear-quadratic (LQ) control class will be the main framework where both Markovian and non-Markovian feedback controls will be studied. The interpretation of the integrals with respect to B^H is in the Skorohod sense. (Received September 19, 2010)

1067-60-1194 **Li Zhu*** (david8229@gmail.com), 1630 NE Valley Rd. X106, Pullman, WA 99163, and **Haijun Li**. *Sharp Bounds for Multivariate Coherent Risk Measures.*

A central topic in financial and insurance mathematics is the search for new methods to estimate accurately extreme risk (or tail risk) for multivariate financial portfolios. Empirical data show that tail risk is often fueled by extreme dependence among assets, but their quantitative relations are largely unknown. This research analyzes tail risk for multivariate financial portfolios in terms of extreme dependence, using tail conditional expectation (TCE). The vector-valued TCE, as a multivariate coherent risk measure, corresponds to a set of deterministic vectors which represent portfolios of extra capitals needed so that the resulting positions are acceptable to regulator/supervisor. While TCE is preferable than the popular risk measure Value-at-Risk, the vector-valued TCE lacks tractable expressions for statistical analysis. In this talk, we present tractable sharp lower and upper bounds for vector-valued TCEs, and discuss the asymptotic properties of these bounds using the theory of multivariate regular variation. Several simulation results for various multivariate distributions are also provided to illustrate our bounds and their monotonicity properties. Our results can be applied for accurate estimates and analysis of extremal risks in quantitative risk management. (Received September 20, 2010)

1067-60-1301 **Jie Xiong*** (jxiong@math.utk.edu), Department of Mathematics, The University of Tennessee, 104 Aconda Court, Knoxville, TN 37996-1000. *SBM as the unique strong solution to an SPDE.*

A stochastic partial differential equation (SPDE) is derived for the super Brownian motion regarded as a distribution function valued process. The strong uniqueness for the solution to this SPDE is obtained by a connection between SPDEs and backward doubly stochastic differential equations. Similar results are also proved for the Fleming-Viot process. A further uniqueness result is obtained when the branching rate or the spatial motion of the particles depends on the population in a suitable way. As a consequence, the uniqueness in law for a class superprocesses with interaction is derived. (Received September 20, 2010)

1067-60-1328 **Daniel Siu*** (danielpaulsiu@gmail.com), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700, and **Gangaram S Ladde** (gladde@usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *Stochastic Hybrid Dynamic Model for Risk Process.* Preliminary report.

A study of a class of multidimensional stochastic hybrid dynamic model is investigated. The model consists of continuous and discrete dynamics. The parameters of the continuous dynamic switch according the discrete dynamic. The discrete dynamic is governed by a non-homogeneous Poisson process. Under certain conditions, the solution to the multidimensional model can be obtained. For the one-dimensional case some probabilistic properties are derived. Applications to the risk theory are discussed. (Received September 20, 2010)

1067-60-1358 **Jacqueline Banks** (jbank003@student.ucr.edu), **Scott Garrabrant** (scott@garrabrant.com) and **Mark L Huber*** (mhuber@cmc.edu), 850 Columbia Avenue, Claremont, CA 91711, and **Anne Perizzolo** (aperizzolo11@students.claremont.edu). *Using TPA to count linear extensions.*

A linear extension of a poset P is a permutation of the elements of the set that respects the partial order. Let $L(P)$ denote the number of linear extensions. It is a #P complete problem to determine $L(P)$ exactly for an arbitrary poset, and so randomized approximation algorithms that draw randomly from the set of linear extensions are used. In this work, the set of linear extensions is embedded in a larger state space with a continuous parameter β. The introduction of a continuous parameter allows for the use of a more efficient method for approximating $L(P)$ called TPA. Our primary result is that it is possible to sample from this continuous embedding in time that as fast or faster than the best known methods for sampling uniformly from linear extensions. For a poset containing n elements, this means we can approximate $L(P)$ to within a factor of $1+\epsilon$ with probability at least $1-\delta$ using an expected number of random bits and comparisons in the poset which is at most $O(n^3(\ln n)(\ln L(P))^2\epsilon^{-2}\ln\delta^{-1})$. (Received September 20, 2010)

1067-60-1435 **T E Govindan*** (tegovindan@yahoo.com), Departamento de Matematicas, ESFM, Instituto Politecnico Nacional, Edificio 9, Zacatenco, 07320 Mexico, D.F., Mexico, Mexico. *Some results on existence and uniqueness of mild solutions of neutral SPDEs.*

This paper studies neutral stochastic partial differential equations (SPDEs). Our goal in this talk is to present some of the recent developments on the existence and uniqueness of a mild solution of SPDEs by exploiting some properties of stochastic convolution integrals and using the semigroup theory. (Received September 21, 2010)

1067-60-1441 **Vadim Kostrykin** and **Jurgen K Potthoff*** (potthoff@math.uni-mannheim.de), Institute of Mathematics, University of Mannheim, D-68131 Mannheim, Germany, and **Robert Schrader**. *Brownian Motions on Metric Graphs.*

Metric graphs are graphs whose edges are isomorphic to either compact intervals or to the positive half line, and which thereby inherit a natural metric structure. Over the last years metric graphs became important as an underlying structure of models in many domains of science. A Brownian motion on a metric graph is by definition a strong Markov process with càdlàg paths which are continuous up to the lifetime, and which away from the vertices is equivalent to a standard one dimensional Brownian motion. In this talk, all Brownian motions on a metric graph are characterized and their paths are constructed. (Received September 21, 2010)

1067-60-1460 **Aurel Iulian Stan*** (stan.7@osu.edu), 1465 Mount Vernon Avenue, Marion, OH 43302. *Gaussian Calculus and Wick Products (Joint work with Paolo Da Pelo and Alberto Lanconelli from the University of Bari, Italy).* Preliminary report.

In the definition of the Gaussian stochastic integral, the integrand is not multiplied by the random infinitesimal dB(t) through the usual point-wise product, but through the Wick product. For this reason, the classic Newton-Leibniz fundamental theorem of Calculus does not work with the point-wise product and the famous Ito formula must be used instead. However, if one replaces the point-wise product with the Wick product, then the Newton-Leibniz formula works, and the whole theory of Gaussian stochastic integration resembles perfectly the classic theory of Riemann integration. For this reason, we believe that the natural product of the theory of Gaussian stochastic integration is the Wick product, and through its use, there is no need for Ito formula, but the classic rules of integration discovered by Leibniz are valid if one uses this product. The most important inequality used in Analysis, that guarantees the integrability of the product of two functions, is Holder inequality. We have found an analogue of the Holder inequality for the Gaussian Wick product. (Received September 21, 2010)

1067-60-1489 **John C. Wierman** and **Matthew R.A. Sedlock*** (msed84@jhu.edu), Dept. of Applied Mathematics and Statistics, 100 Whitehead Hall, Baltimore, MD 21218. *On equality of critical exponents in inhomogeneous percolation models.* Preliminary report.

In the inhomogeneous bond percolation model, bonds in a given lattice are open with different probabilities. Because of this, the percolation threshold is expressed as a critical surface, rather than as a single point as in the homogeneous model. Near the critical surface, it is believed that several functions of interest, such as the percolation probability function and the expected cluster size, behave according to certain power laws. The exponents in these power laws are known as critical exponents. Because the percolation threshold is given by a critical surface, it is necessary to look at directional power laws and, as a result, directional critical exponents in studying their behavior. We show a range of directions in which equality of directional critical exponents can be established, and that the range of directions depends on which point on the critical surface we study. (Received September 21, 2010)

1067-60-1491 **John C. Wierman*** (wierman@jhu.edu), Dept. of Applied Mathematics & Statistics, Johns Hopkins University, Baltimore, MD 21218, and **Matthew R. A. Sedlock**. *On equality of critical exponents in homogeneous percolation models.* Preliminary report.

In percolation theory, the clustering behavior in an infinite random graph model is studied. An important quantity is the percolation threshold, which is often interpreted as a phase transition point. Several functions of interest in percolation models are believed to exhibit power law behavior near the percolation threshold. If such power law behavior is valid, the exponents in the power laws, called critical exponents, may be defined in terms of limits of the functions. It has only been proved that these limits exist for a few infinite lattice graphs. Assuming that their defining limits exist, we prove that the critical exponents of certain pairs of lattices are equal. The result applies to a large class of dual pairs of bond percolation models and a large class of matching pairs of site percolation models. The reasoning relies on stochastic ordering and Russo's formula, simplifying a previous proof that was more computational. (Received September 21, 2010)

1067-60-1573 **Patrick R Driscoll*** (pdriscol@math.ucsd.edu), 9500 Gilman Drive, #0112, La Jolla, CA 92093. *Smoothness of Density for the Area Process of Fractional Brownian Motion.* Preliminary report.

We consider a process given by a two-dimensional fractional Brownian motion with Hurst parameter $\frac{1}{3} < H < \frac{1}{2}$, along with an associated Lévy area, and prove the smoothness of a density for this process with respect to Lebesgue measure. (Received September 21, 2010)

1067-60-1587 **Tai Melcher*** (melcher@virginia.edu), University of Virginia, Department of Mathematics, Charlottesville, VA 22903. *Heat kernel measures on a class of infinite dimensional Lie groups.*

Bruce Driver and Masha Gordina recently introduced a class of infinite dimensional "Heisenberg-like" Lie groups based on Len Gross' abstract Wiener space. They studied properties of the heat kernel measure on these groups. I will discuss some results for heat kernel measure on closely related groups which in some ways generalize Driver and Gordina's model. (Received September 21, 2010)

1067-60-1618 **Michelle R Lacey*** (mlacey1@tulane.edu), Department of Mathematics, 6823 St. Charles Avenue, New Orleans, LA 70118. *Statistical Modeling of Methylation Patterns in Ovarian Carcinomas.*

Changes in cytosine methylation at CpG nucleotides are observed in many cancers, but the biological mechanisms responsible for these changes are not yet fully understood. Previously developed stochastic models for cancer-related methylation change have either treated CpG sites independently or employed a context dependent approach to adjust model parameters according to regional methylation levels. However, our analyses of double-stranded methylation patterns in 0.2 kb regions of the tandem repeats Sat2 and NBL2 have detected small clusters of identically methylated sites in close proximity that could not be explained by random variation. These findings suggest a high degree of site-to-site dependence, and we have developed a neighboring sites model for methylation change as an alternative approach. We have compared the independent sites, context dependent, and neighboring sites models in their ability to generate simulated sequences statistically similar to our Sat2 and NBL2 carcinoma samples, and we demonstrate that the neighboring sites model is preferred in the majority of the cases considered. (Received September 21, 2010)

1067-60-1620 **Gustavo Didier*** (gdidier@tulane.edu), 6823 St Charles Avenue, New Orleans, LA 70118, and **Vladas Pipiras**. *Self-similarity and long range dependence: some recent developments for the multivariate setting.*

A stochastic process is said to be self-similar (s.s.) when its law scales according to a power $0 < \mathrm{H} < 1$, the so-called the Hurst parameter. An example of a self-similar process is the classical Brownian Motion. Long range dependence (LRD) has been gaining great popularity in Time Series Analysis. It is presently used to model Internet data traffic, water levels of rivers, and many other phenomena of interest.

There are many connections between s.s. processes and LRD. This talk is about the multivariate setting, for which there are still many open research questions. We focus on a class of self-similar processes, called Operator Fractional Brownian Motions (OFBMs). We establish integral representations of OFBMs and study issues such as spectral properties and time reversibility. We also look into the identifiability of the parametrization by studying the symmetry groups of OFBMs. In low dimension, we provide a full description of the latter, but we also show that, in any dimension, the parametrization of OFBM is identifiable in general, in the topological sense. (Received September 21, 2010)

1067-60-1648 **Elton P Hsu*** (ehsu@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208. *Stochastic Completeness and Escape Rate of Brownian Motion on a Riemannian Manifold.*

A geodesically complete Riemannian manifold is called stochastically complete if its minimal heat kernel is integrated to one. Since the heat kernel is the transition density function of Riemannian Brownian motion, a manifold is stochastically complete if and only if Brownian motion does not explode. To find a proper geometric condition for stochastic completeness is an old geometric problem. The first result in this direction was due to S. T. Yau, who proved that a Riemannian manifold is stochastically complete if its Ricci curvature is bounded from below by a constant. It has been know for quite some time that the property of stochastic completeness is intimately related to the volume growth of a Riemannian manifold. We study stochastic completeness by looking at the more refined question of upper escaping rates of Riemannian Brownian motion. We show how the Neumann heat kernel, time reversal of reflecting Brownian motion, and volumes of geodesic balls come together and give an elegant and often sharp upper bound of the escaping rate solely in terms of the volume growth function without any extra geometric restriction. This is a joint work with Guang Nan Qin of Institute of Applied Mathematics of the Chinese Academy of Sciences. (Received September 21, 2010)

1067-60-1705 **Richard Freedman*** (freerg8@wfu.edu) and **Errin Fulp** (fulp@wfu.edu). *Weighted and Unweighted Random Walks of Multiple Entities on a Torus-Shaped World.* Preliminary report.

A new approach to network security involves multiple "agents" walking about a network in search of suspicious activity. An Ant-Colony Organization (ACO) algorithm allows the initially random walk to become more guided as the target is located by some of the agents. The mean number of steps it takes for an agent to "succeed" and find such a target is called the expected hit time. In this talk, we will discuss the expected hit time and the probabilities of success and failure for these walks over time using a discrete dynamical system based on a network that creates a torus-shaped world. Particular focus will be placed on the worst-case (fully random walk) and best-case (fully weighted random walk) scenarios for x agents in the network. (Received September 21, 2010)

1067-60-1707 **Olympia Hadjiliadis*** (ohadjiliadis@brooklyn.cuny.edu), 365 5th ave Rm 4208, New York, NY 10016. *Drawdowns and drawups.*

In this work we consider the joint distribution of drawdowns and drawups of Brownian motion with positive and negative drift respectively. The drawdown is defined as the first time that the current drop of the process from the running maximum reaches a certain threshold while the drawup is defined as the first time that the current rise of the process from the running minimum. In particular we demonstrate that it is possible to write the joint Laplace transform of the drawdown when the drawdown precedes the drawup as a ratio of the Laplace transforms of each of the individual Laplace transforms of the drawdown and the drawup respectively. Using this decomposition we investigate the cases in which it is possible to express the joint distribution of drawdowns and drawups in terms of the joint distribution of first hitting times to upper and lower thresholds. We discuss the usefulness of this decomposition to sequential statistics and financial risk management. (Received September 21, 2010)

1067-60-1710 **Mark Burgin** (mburgin@math.ucla.edu), UCLA, Westwood, CA, **Mark Dela*** (mark.dela@gmail.com), Mark Dela, Department of Mathematics and Statistics, California State Polytechnic Univ., Pomona, Pomona, CA 91768, **Alan Krinik** (ackrinik@csupomona.edu), Alan Krinik, Department of Mathematics and Statistics, California State Polytechnic Univ., Pomona, Pomona, CA 91768, and **David Luu** (dluu@csu.fullerton.edu), Alan Krinik, Department of Mathematics and Statistics, California State Polytechnic Univ., Pomona, Pomona, CA 91768. *Birth-Death Markov chains Having Hyper-Probability Transitions.*

We consider birth-death Markov chains having transition hyper-probabilities rather than probabilities. Under mild restrictions, the ideas of steady state distributions and gamblers ruin probabilities generalize and have the same form as the classical results. Examples of hyper- probabilistic birth-death chains exhibiting real behavior (such as: real ruin probabilities or real steady state distributions or steady state distributions with real averages) will be discussed. (Received September 21, 2010)

1067-60-1734 **David L. Skoug*** (dskoug@math.unl.edu), University of Nebraska-Lincoln, Department of Mathematics, 203 Avery Hall, 1144 T St, Lincoln, NE 68588-0130. *Comparing the distributions of various supremums on two-time parameter Wiener space.* Preliminary report.

Let $Q = [0, S] \times [0, T]$ and let $C_2[Q]$ denote the Wiener space of all real-valued continuous functions $x(s,t)$ on Q with $x(0,t) = x(s,0) = 0$ for all $(s,t) \in Q$. Included in our results is the fact that

$$\lim_{c \to +\infty} \left\{ \frac{P\left(sup_{\partial Q} x(s,t) \geq c\right)}{P\left(\ sup_{Q} x(s,t) \geq c\right)} \right\} = \frac{2}{3}$$

where ∂Q denotes the boundary of Q. (Received September 21, 2010)

1067-60-1785 **Chelsea R Ross*** (zcrr23@goldmail.etsu.edu) and **Brooks E Smith** (bsmith26@nd.edu). *Predictive Methods in Coupon Collection.* Preliminary report.

Given a series of "n" coupons and their respective probabilities, finding the expected time to collect at least one of each coupon is a problem that has been studied thoroughly in many forms. At the 2010 ETSU REU, the inverse to this problem was studied: given a full coupon collection, make accurate predictions about the probability of each coupon. The frequency method is known on average to underestimate the probabilities of coupons in certain positions, such as the final coupon collected. This presentation gives and overview of our statistical findings concerning the efficacy of various predictive methods, as well as some theoretical justifications for the methods chosen to be tested. (Received September 22, 2010)

1067-60-1787 **Ross P Hilton*** (hiltrp6@wfu.edu), Department of Mathematics, Wake Forest University, Winston Salem, NC 27109, **Kenneth S Berenhaut** (berenhks@wfu.edu), Department of Mathematics, Wake Forest University, Winston Salem, NC 27109, and **James W Chernesky**, Department of Mathematics, Wake Forest University, Winston Salem, NC 27109. *A New Asymptotic Expansion for Distributions of Sums of Random Variables.*

In this talk we introduce a local limit theorem for probability distributions of sums of independent and identically distributed random variables. In comparison with Edgeworth-type theorems, advantages include markedly improved asymptotic results in the case of symmetric random variables and ease of computation of the main error term and asymptotic crossing points. (Received September 21, 2010)

1067-60-1941 **Gangaram S Ladde*** (gladde@usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *Hybrid network dynamic inequalities under hereditary and random perturbations.* Preliminary report.

In this work, a mathematical model for interconnected dynamic phenomenon evolving under hereditary, random and different measure chains with state dependent discrete events is formulated. By introducing an arbitrary pair of functional of a pair of flows (measured dynamic flows), a hybrid network dynamic inequalities with corresponding comparison hybrid network dynamic system is outlined. An arbitrary pair of functional of dynamic flows evolving in two different time scales satisfying an interconnected system of systems of hybrid dynamic inequalities under hereditary and random perturbations is estimated by the corresponding comparison system of systems of impulsive hybrid dynamic equations. Moreover, by employing vector Lyapunov/energy functions as functional of hybrid dynamic flows under the action of both hereditary and random perturbations, several variational comparison results are developed to estimate solution processes of nonlinear nonstationary stochastic hereditary hybrid dynamic system in systematic and coherent manner. The obtained results extend and generalize the existing results in a systematic and unified way. (Received September 22, 2010)

1067-60-1963 **Victor Goodman*** (goodmanv@indiana.edu), Mathematics Department, Indiana University, Bloomington, IN 47405. *Sensitivity Analysis of Expected Values.*

The expected value $E[f(X_t)]$ may depend on several parameters defining the diffusion process X_t. Information concerning the partial derivative of the expectation on each parameter (its sensitivity) is of great value in applied situations.

In 1999, Fournie, Lasry, and their co-authors introduced a method for computing sensitivities when the function $f(x)$ is not smooth. Their method, using Malliavin calculus to differentiate the diffusion itself, allows answers to be obtained with stochastic weights which are not unique. We discuss the generality of these weights and the limitations on the use of this method. (Received September 22, 2010)

1067-60-1978 **Kandethody M Ramachandran*** (ram@usf.edu), Department of Mathematics and Statistics, Tampa, FL 33620-5700. *Machine learning methods in Finance.* Preliminary report.

A brief survey of reinforcement learning (RL) and other machine learning methods and its applications to the fields of asset allocation, stock trading, and inventory management will be given. There are wide varieties of financial problems such as dynamic asset allocation to derivative pricing and hedge that are being modeled as decision theoretic framework and solved by the dynamic programming algorithms. Due to lack of information on the transition probabilities as well as due to its 'curse of dimensionality', where computational time required for generation of optimal strategies grows exponentially in the number of variables involves, is inadequate in solving real world problems. Reinforcement learning methods offer sub-optimal procedures, far more efficient than DP procedures, to solve sequential decision problems. Reinforcement learning algorithms find approximate solutions to dynamic programming problems and can do so in an on-line mode. This area has seen tremendous growth in the area of artificial intelligence, but recently, increasingly used in financial data analysis. In addition, we will also look at some other machine learning methods that is being effectively used in financial analysis. (Received September 22, 2010)

1067-60-1980 **Jinghan Meng*** (jmeng@mail.usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700, and **Gangaram S Ladde** (gladde@usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *Generalized Random Differential Inequalities and Applications.* Preliminary report.

In the present work, we initiate the study of generalized random differential inequalities. We present several results to illustrate the significance of the developed results. Moreover, we obtain estimates for the solution processes of fractional differential equations with random parameters. (Received September 22, 2010)

1067-60-2015 **Vindya Kumari Pathirana*** (vkumari@mail.usf.edu), University Of South Florida, Department of Mathematics, 4202 E. Fowler Avenue, Tampa, FL 33620, and **Kandethody M. Ramachandran**. *Cluster K and probabilistic-Nearest-Neighbor Predictions in Foreign Exchange Markets.*

Foreign exchange rate forecasting through non-linear dynamical systems is becoming more and more relevant due to the nature of the data. Nearest Neighbor Algorithms which are among the most popular non-linear pattern recognition methods outperform the available linear forecasting methods when consider the high frequency foreign exchange data. In this work, we adapt cluster K-nearest neighbor, and probabilistic nearest neighbor algorithms for foreign exchange rate data. We compare the performances of these methods with the traditional methods, such as K-Nearest neighbor, transforming their forecasts in to a technical trading rule. (Received September 22, 2010)

1067-60-2041 **James P Ferry*** (ferry@metsci.com), 1818 Library Street, Suite 600, Reston, VA 20176. *Tracking communities with a graph-valued Markov process.*

The simple homophily model for random graphs is generalized to a (G, π)-valued Markov process, where G is a graph and π a partition of its vertices into groups. From this, a Bayesian filter is derived which processes a time-varying graph into a probability distribution over the partitions of its vertices at any time. This Bayesian filter is then marginalized to a system of evolution equations for the pairwise group co-membership probabilities of the vertices. It is shown how these pairwise probabilities may be used to generate group partitions with maximal expected utility. The results are applied to the community detection problem in social network analysis, producing (a) an algorithm with state-of-the-art accuracy which provides probabilistic output instead of merely a single group partition, and (b) a generalization which tracks communities in dynamic network data. (Received September 22, 2010)

1067-60-2046 **Ian Pierce*** (s-ipierce1@math.unl.edu), Avery Hall 203, University of Nebraska - Lincoln, Lincoln, NE 68588. *Reflection principle(s) for the multiple parameter Wiener process?* Preliminary report.

It is well known that the single parameter Wiener process exhibits a reflection principle, while in the multiple parameter setting, the very notion of a reflection principle becomes less clear. We will discuss several possible notions of a reflection principle for the multiple parameter Wiener process, and will examine their applicability using very simple tools and techniques. (Received September 22, 2010)

1067-60-2076 **Peter Gacs*** (gacs@bu.edu), Computer Science Department, Boston University, 111 Cummington Street, Boston, MA 02215. *A constructive law of large numbers with applications.*

Let $X_1, X_2, \dots$ be a sequence of identically distributed, pairwise independent nonnegative integer random variables with distribution P. Let the expected value be $\mu < \infty$. Let $S_n = \sum_{i=1}^{n} X_i$. It is well-known that S_n/n converges to μ almost surely. We show that this convergence is effective in (P, μ). In particular, if P, μ are computable then the convergence is effective. On the other hand, if the convergence is effective in P then μ is computable from P.

This theorem can be used to show an effective renewal theorem, which then can be used to prove an effective ergodic theorem for countable Markov chains. The last result is a special case of effective ergodic theorems proven by Avigad-Gerhardy-Towsner and Galatolo-Hoyrup-Rojas, but we hope that the direct constructivization of the probability-theory proofs is still useful. (Received September 22, 2010)

1067-60-2135 **Krishna Kaphle***, Department of Mathematics, Texas Tech University, Lubbock, TX 79409, and **Frits H Ruymgaart** and **George Gaines**. *A test for testing the equality of covariance operators.*

The generalization of multivariate statistical procedures to infinite dimensions naturally requires extra theoretical work. In this paper, we will focus on testing the equality of covariance operators. We further elaborate on a procedure derived from the Union Intersection principle in conjunction with a Likelihood Ratio test. This procedure leads to a test statistics which is the largest eigenvalue of a product of operators. We Generalize this procedure by using a test statistic that is based on the first $m \in \mathbb{N}$ largest eigenvalues. Perturbation theory of operators and functional calculus of covariance operators are extensively used to achieve required asymptotics. It is shown that the power of the test is improved with inclusion of more eigenvalues. We perform simulations to verify the testing procedure, using samples from two equivalent Gaussian distributions. (Received September 22, 2010)

1067-60-2138 **Avanti Athreya**, Department of Mathematics, PO Box 90320, Durham, NC 27708-0320, **John Fricks**, Department of Statistics, 326 Thomas Building, University Park, PA 16802, **Peter R Kramer**, Department of Mathematical Sciences, 110 8th Street, Troy, NY 12180, and **Scott A McKinley*** (scott.mckinley@ufl.edu), Department of Mathematics, 358 Little Hall, PO Box 118105, Gainesville, FL 32611-2002. *Cooperative dynamics of kinesin and dynein type molecular motors.*

Central to cell function is the intracellular transport of biological materials constructed in and near the cell nucleus that must be delivered to destinations throughout the cell body. Among the key players in this process are biochemical molecular motors from the kinesin and dynein families. While experiments and early analysis have had success in studying the dynamics of such motors moving intracellular cargo individually, we will use techniques from SDE theory and stochastic averaging to analyze the behavior of motor-cargo complexes when multiple motors are working to move the same cargo. (Received September 22, 2010)

1067-60-2169 **Ioana Dumitriu*** (dumitriu@u.washington.edu), University of Washington, Department of Mathematics, BOX 354350, Seattle, WA 98195, and **Soumik Pal**. *Sparse Regular Random Graphs: Spectra and Eigenvectors.*

Regular graphs are widely studied in connection to Markov chains and expanders, as well as networks. It is interesting, therefore, to understand what a "typical" object from this class looks like, and what kind of properties it exhibits. This can be accomplished, in many cases, by studying the random regular graph.

Of the quantities that characterize the random regular graph, we will focus on eigenvalues and eigenvectors, particularly in the regime when the size of the graph, as well as the degree, grow to infinity (the latter, much slower than the former). We will describe the limiting shape of the empirical eigenvalue distribution, list some eigenvector properties, and mention what is known about other models.

This is joint work with Soumik Pal. (Received September 22, 2010)

1067-60-2193 **Mark Allenby*** (mark.allenby@pepperdine.edu), Pepperdine University, 24255 Pacific Coast Highway, Malibu, CA 90263, and **Kym Louie** and **Marina Masaki**. *A Point Process Model for Simulating Gang Violence.*

Gang violence is a prevalent problem in cities across the United States. A way of simulating and predicting occurrences of gang on gang crimes is useful to counteract this problem. In this paper, a point process method is presented to model gang-on-gang crimes. The Hawkes process has historically been used to model earthquake and aftershock occurrences, but has clear application to criminology due to the repeat and retaliatory nature of crimes.

The Hawkes process, a self-exciting point process, is introduced as a temporal model for crimes between gangs. A marked Hawkes process is then used to describe directional rivalry strength between pairs of gangs. This directional Hawkes Process is then expanded to simulate crimes not only temporally but also spatially. Finally, we simulated a multi-gang system using a modified version of the simple branching process generally used to simulate the Hawkes process. This model distributes crimes through space and time, assigns the crime to pair of rival gangs and then directionality within this pair. The parameters of all models were fit using penalized maximum log-likelihood estimation with 1208 gang related crimes between 1999 and 2002 in the policing district of Hollenbeck located in the city of Los Angeles. (Received September 22, 2010)

1067-60-2283 **Sarah N Bryant*** (bryants@dickinson.edu), Dickinson College, Dept. of Mathematics and Computer Science, Carlisle, PA 17013. *Counting and Partition Function Asymptotics for Subordinate Killed Brownian Motion.*

Given d-dimensional Brownian motion B, if we first kill B in a domain D and then subordinate by a one-dimensional increasing Levy process T (the subordinator with Laplace exponent φ), the resulting process is subordinate killed Brownian motion. This process has associated spectrum $\{\mu_j\}_{j\geq 1}$ and transition density $p_D^{\varphi}(t,x,y)$. We consider the counting function $N_D^{\varphi}(\lambda) = \#\{j : \mu_j \leq \lambda\}$ and partition function $Z_D^{\varphi}(t) = \int_D p_D^{\varphi}(t,x,x)dx$. In this talk, we prove first- and second-order asymptotics of the counting function for subordinate killed Brownian motion on certain domains. By using the Karamata Tauberian theorem we then give first-order asymptotics of the associated partition function for various subordinators. We include second-order asymptotics of the partition function for a specific set of subordinators, namely the $\frac{\alpha}{2}$-stable subordinators. (Received September 22, 2010)

1067-60-2292 **Steven T. Morrow*** (stmorrow@indiana.edu), Indiana University, Department of Mathematics, 831 East 3rd St, Bloomington, IN 47405. *A 'Cousin of Coboundary' Theorem for $C[0,1]$-Valued Random Fields with Moment Conditions.* Preliminary report.

For a given strictly stationary sequence of real-valued random variables and a given $p \in [1, \infty)$, it has been shown that the partial sums are L^p-bounded if and only if the sequence consists of the successive differences of another sequence which is also strictly stationary and has finite p-norm. This has been generalized to nonstationary real-valued random fields indexed by $\mathbb{Z}^d$, and to include the index $p = \infty$. Here we extend these results to nonstationary $C[0,1]$-valued random fields satisfying an additional moment condition. (Received September 22, 2010)

1067-60-2317 **Robert J Rovetti*** (rrovetti@lmu.edu), Mathematics Dept., One LMU Drive, Los Angeles, CA 90045. *Period-2 behavior and spatial correlations in a probabilistic lattice model of the cardiac cell.*

We study a system of locally-coupled stochastically-excitable elements in a 2D lattice that replicates physiological features of the cardiac cell, including threshold excitation, refractory period, global periodic forcing signal, and spatial nearest-neighbor interactions. A difference equation is derived which models the expected excitation rate (E) at each beat. We then find conditions under which E can undergo a bifurcation to period-2 behavior (mimicking the pathological condition known as "alternans"), and further show, via local structure approximation, that these conditions are dependent on the spatial correlation that results from neighbor-to-neighbor coupling. We finally consider the continuous-time case and allow for higher-order (cascading) spatial interactions, which can result in the formation of excitation waves. (Received September 22, 2010)

1067-60-2319 **Komi Segno Messan*** (komimessan@gmail.com), 5415 Waterpoint dr, Browns summit, NC 27214, and **Michael Lynch** and **Matthew Ackerman**. *Average time until fixation of mutant allele in a given population.* Preliminary report.

The main idea in population genetic is evolution. Evolution is much different from most studies in biology for the fact that its insights are theoretical rather than experimental. Most evolutionary studies concern the frequencies or the fitness of genotype in a population.Evolution can also be explain by two forces: forces that introduce variation in phenotypic character such as eye colors, height or certain behaviors and forces that make some traits to become more commmon or rare. The main cause of variation is mutation. Mutation is a change in the DNA sequence of a cell's genome. One of the most important problems in population genetics is how long it takes for a gene to go to fixation. A mutant gene in a given population will eventually be lost or established. The particular interest of this research is to know the mean time for a mutant gene to become fixed in a population with the exclusion of the case when this gene is lost. A diploid population of N individuals is considered with a forward and backward mutations. using a set of nonlinear equations, the genotype frequencies are calculated so that the equilibrium points can be determined for an infinite population. With the diffusion theory, an approximation of the time to fixation is calculated for a finite population. (Received September 22, 2010)

1067-60-2320 **Constantine Georgakis*** (cgeorgak@depaul.edu), Department of Mathematics, DePaul University, 2320 N. Kenmore, Chicago, IL 60614. *Analogue of Hardy's Inequality for a Renewal Process.* Preliminary report.

An analogue of Hardy's lp inequality, concerning the discrete Hausdorff transformation generated by the sum of a sequence of exchangeable Bernoulli random varibles,is presented for a linear transformation generated by the sum of a renewal process. (Received September 22, 2010)

1067-60-2409 **Rene Carmona*** (rcarmona@princeton.edu), Dept of OR and Financial Engg, Princeton University, Princeton, NJ 08544. *Emissions Option Pricing and Singular BSDEs.* Preliminary report.

We give a brief review of the equilibrium theory of cap-and-trade schemes in order to motivate the assumptions of several reduced form models which we present and compare. Pricing and hedging options in these models lead to the solution of forward-backward stochastic differential equations with a non-smooth terminal condition, and we spend the second part of the talk analyzing these equations, demonstrating among other things that expected results do not always hold true. (Received September 23, 2010)

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1067-62-170 **Brian T Rooks*** (btrooks@email.unc.edu), 1222 Abbotts Creek Circle, Kernersville, NC 27284, and **Amy C Schumacher** (acschuma@bsc.edu), 258 Bouldincrest Ave., Collierville, TN 38017. *The Power Cauchy Distribution: Derivation, Description, and Composite Models.*

First, a new two-parameter member of the transformed beta family (Venter 1983), called the Power Cauchy distribution, is derived and described. The new model has increased statistical usefulness when compared to other members of the transformed beta family because of the thicker upper tail of the density. Second, this distribution is combined with the Pareto distribution using the procedure introduced by Cooray and Ananda (2005). This combination increases the thickness of the right tail of the distribution in order to more accurately fit highly positively skewed data. Third, this model is improved upon with the addition of a mixing parameter as was recommended by Scollnik (2007). Using medical data sets, parameter estimation by the maximum likelihood method and related goodness of fit tests are performed in order to compare the models with other known models. (Received July 28, 2010)

1067-62-581 **George O Mohler*** (georgemohler@gmail.com), 713 Harding Ave, San Jose, CA 95126. *Point process modeling and estimation of near-repeat effects in crime data.*

Highly clustered event sequences are observed in crime data due to various patterns of criminal behavior. We show how these "near-repeat" effects can be incorporated into macroscopic models of crime using self-exciting point processes similar to models of earthquake aftershock sequences. We discuss both parametric and nonparametric approaches, illustrated with burglary and gang data provided by the Los Angeles Police Department. (Received September 10, 2010)

1067-62-595 **Sougata Dhar** (sougata_dhar@ymail.com), Department of Mathematics, University of Texas - Pan American, 1201 West University Drive, Edinburg, TX 78539, and **Santanu Chakraborty*** (schakraborty@utpa.edu), Department of Mathematics, University of Texas - Pan American, 1201 West University Drive, Edinburg, TX 78539. *Zero Inflated Exponential Distribution.*

There have been a lot of studies on the Zero Inflated versions of these discrete distributions, like Zero Inflated Poisson and Zero Inflated Negative Binomial distributions. They arise naturally in the literature when one aims to model count data sets with more than usual number of zeros. But so far there had been no relevant study regarding Zero Inflated versions of the well known continuous probability distributions, say, Exponential or Gamma or Normal distributions. However, there could be real life situations where one can come across Zero Inflated version of an Exponential or a Normal distribution. For example, the life span of an electric bulb is generally assumed to be Exponential. But if a cheap brand of bulb exists in the market, it may have a shorter life span as compared to an electric bulb of a standard brand. In that case, the probability at zero or on an interval around zero may be more than that that for a usual Exponential distribution. In fact, Zero Inflated version of the Exponential distribution is obtained by inflating the usual exponential probability around zero and deflating it away from zero. In this talk, we will be studying the Parametric and Bayesian statistical issues for the Zero Inflated version of the Exponential distribution and its variants. (Received September 10, 2010)

1067-62-719 **Ali A Al-Sharadqah*** (alsha1aa@gmail.com), 411 Hickory Knolls, Birmingham, AL 35226. *A novel Algorithm for ellipse fitting.* Preliminary report.

Fitting simple contours to observed points is a basic task in pattern recognition and computer vision. The most important contours are circles and ellipses. Many practical algorithms have been developed for such curves to scattered data, but their statistical analysis is difficult when both coordinates of observed points are measured with errors. In modern statistics, the corresponding assumptions are known as Errors-In-Variables (EIV) model. Al-sharadqah and Chernov developed a new approach to study the statistical properties for curve fitting. This allows them to investigate the most popular circle fits (geometric fit and other algebraic fits such as Kasa, Taubin and Pratt) and show exactly why and by how much circle fits differ from each other. Also, they constructed a new algebraic (non-iterative) circle fitting algorithm that outperforms all the existing methods, including the geometric fit by removing the significant part of the second order bias. Inspired by their work, we study the statistical properties of ellipse fits (Algebraic, GRAF), which are much harder than circle fits, and developed new ellipse fits by eliminating the second order bias completely. These fits again outperform the existing fits (Received September 14, 2010)

1067-62-1011 **Arnut Paothong***, Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700, and **Gangaram S Ladde** (gladde@usf.edu), Department of Mathematics and Statistics, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620-5700. *Dynamic Modeling of Network Externality.* Preliminary report.

The network externality is an effect that one user of a good or service has on the value of the product to other users. In this work, we focus on modeling network externality processes. The introduction of model leads to a S-shape function to fulfill the network externality concept. We also examine the impact of US banking deposit on US banking asset in the sense of network externality concept. This is achieved by the application of the nonlinear regression analysis for network externality function. (Received September 17, 2010)

1067-62-1111 **David Papp*** (dpapp@rutcor.rutgers.edu), 640 Bartholomew Rd, Piscataway, NJ 08854. *Optimal designs for rational function regression.*

We consider optimal non-sequential designs for a large class of (linear and nonlinear) regression models involving polynomials and rational functions with heteroscedastic noise also given by a polynomial or rational weight function. The proposed method generates a polynomial whose zeros are the support points of the optimal approximate design, and generalizes a number of previously known results of the same flavor. The method is based on a mathematical optimization model that can incorporate various criteria of optimality and can be solved very efficiently by well established numerical optimization methods. In contrast to previous optimization-based methods proposed for similar design problems, it also has theoretical guarantee of its efficiency. After discussing linear models, applications for finding locally optimal designs for nonlinear regression models involving rational functions are presented, then extensions to robust regression designs, and trigonometric regression are shown. As a corollary, an upper bound on the size of the support set of the minimally-supported optimal designs is also found. (Received September 18, 2010)

1067-62-1144 **Maria E Calzada** and **Holly M Gardner*** (hgardner.nola@gmail.com), 6320 Caldwell Drive, New Orleans, LA 70122. *Preliminary Report on the Power of the Bootstrap Ratio Test for Normality.*

Based off of the results obtained from a simulation study done during the 2009 SCORE program, a new normality test, the Bootstrap Ratio Test, was developed using ratios calculated from bootstrap t confidence intervals. These ratios are compared with critical values computed from Monte Carlo simulation constructed with sample sizes 4 to 45; for confidence levels 0.9, 0.95, and 0.99; for significance levels of 0.1, 0.05, and 0.01; and for 1000 or 2000 bootstrap resamples. A power study is being completed comparing the performance of the Bootstrap Ratio test to the Anderson-Darling, Lilliefors, Shapiro-Wilks normality tests for symmetric and skewed distributions. Preliminary results show that the Bootstrap Ratio Test performs comparably well to the established tests for skewed data. Extended results will be available on the date of presentation. (Received September 19, 2010)

1067-62-1155 **Boubakari Ibrahimou*** (boubakari.ibrahimou@wku.edu), 1293 Sun Ct, Apt G, Bowling Green, KY 42104. *Applying Recurrent Event Survival Analysis on China One child one family policy.* Preliminary report.

China one child one family policy introduced in 1979 as a measure to control the fast growing population has mixed results. A growing number of families have more than one child. One of the reasons is due to "male heir". In this talk we discuss the impact of "male heir" mentality on decision to have multiple children either abiding by or in violation of local governmental regulations. We quantify the impact of "male heir" by means of excessive births based on recurrent event survival models and a sample of data collected in study of medical insurance in Pinggu, Beijing. In this process, we identify and incorporate other determinants (confounders) of decision to have multiple children. These candidate determinants include demographic factors such as education, occupation, income, and family structure. (Received September 19, 2010)

1067-62-1167 **George P Yanev*** (yanevgp@utpa.edu), 1202 West University Drive, Department of Mathematics, The University of Texas - Pan American, Edinburg, TX 78539, and **M Ahsanullah** (ahsan@rider.edu), 2083 Lawrenceville Rd, Rider University, Lawrenceville, NJ 08648. *Characterizations of t-distribution via conditional expectations of order statistics.*

Utilizing regression properties of order statistics, we characterize a family of probability distributions that includes Student's t-distribution with two degrees of freedom among its members. The characterization is extended to Student's t-distribution with more than two degrees of freedom. (Received September 19, 2010)

1067-62-1305 **Jeffrey Liebner*** (liebnerj@lafayette.edu), 500 McCartney Street, Easton, PA 18042, and **Julie Michelman**, **Micah Pearce** and **Jiaqi Li**. *Working with Cubic Splines and Neural Data.* Preliminary report.

Curve fitting attempts to find a smooth function that describes the trend of data given in (x_i, y_i) pairs. Cubic splines, of which smoothing splines are one type, are piece-wise cubic functions commonly used to fit such data. The smoothing spline fit f minimizes the penalized sum of squares $PSS(f) = \sum (y_i - f(x_i))^2 + \lambda \int (f^{''}(x))^2 dx$ where the first term is the residual sum of squares and the second is a global smoothing parameter λ multiplied by a penalty for curvature. Smoothing splines generally perform well unless the curvature of the data is highly variable, in which case they tend to overfit smoother areas and underfit areas with sharp curvature. We develop an algorithm to fit smoothing splines with a variable smoothing parameter, which accounts for local changes in curvature. Our automated algorithm finds the optimal smoothing parameter value at each point using cross validation in a local window and then uses this set of parameter values to calculate the fit. On data with trends that have highly variable curvature, our fits consistently have lower mean integrated squared error and better coverage for confidence intervals than ordinary smoothing spline fits. (Received September 20, 2010)

1067-62-1380 **Lauren Mondin*** (lnm007@shsu.edu), 1900 Avenue I, Lee Drain Building, Suite 420, Sam Houston State University, Huntsville, TX 77340, **Scott Clark**, 1900 Avenue I, Lee Drain Building, Suite 420, Sam Houston State University, Huntsville, TX 77340, **Courtney Weber**, 1900 Avenue I, Lee Drain Building, Suite 420, Sam Houston State University, Huntsville, TX 77340, **Jessica Winborn**, 1900 Avenue I, Lee Drain Building, Suite 420, Sam Houston State University, Huntsville, TX 77340, and **Melinda Holt**, 1900 Avenue I, Lee Drain Building, Suite 420, Sam Houston State University, Huntsville, TX 77340. *Statistical Analysis of Diagnostic Accuracy With Applications to Cricket.*

In the game of Cricket, spectators and officials are interested in making the games as fair as possible. One way to accomplish this is to evaluate the umpires and the correctness of their calls. Estimates of statistical accuracy were used as a basis for comparison. Another way to ensure the objectivity of the game is to be able to, as consistently as possible, determine the winner of the game if it is interrupted for some reason. In the traditional Fifty50 cricket game, the Duckworth-Lewis (DL) method of determining a winner is the preferred procedure. However, with the growing popularity of shorter Twenty20 matches, a new Bhattacharya-Gill-Swartz (BGS) method has also been introduced. We created both frequentist and Bayesian intervals to estimate the true accuracy of each. Using past game data from 2005-2010, we compared the DL and BGS methods using the new accuracy intervals and Receiver Operator Characteristic (ROC) curves, which compare true positives vs false positives. (Received September 20, 2010)

1067-62-1384 **Peiling Wu*** (pwu@math.wsu.edu), 1650NE Valley Rd. B18, Pullman, WA 99163. *Tail Dependence Density of Vine copulas.*

Multivariate extremes can be described by intensity measure or tail dependence function, but these tools become intractable for high-dimensional dependence models, such as vine copulas, which are constructed via successive mixing from bivariate linking copulas according to tree structures. To overcome this problem, we introduce the tail dependence density function to describe the density distribution of multivariate extremes. We show that the tail dependence density function enjoys some desirable operational properties, such as homogeneity, and is equivalent to the intensity measure in analyzing multivariate extremes. In particular, we show that the tail dependence density function of a vine copula can be expressed recursively by the tail dependence density of each pair of adjacent nodes and the tail density functions of linking copulas in lower-dimensions. Such a recursion is especially useful for high-dimensional data analysis. Some examples involving Archimedean copulas are also presented to illustrate the results. (Received September 20, 2010)

1067-62-1418 **Galen I Papkov*** (gpapkov@fgcu.edu), 10501 FGCU Blvd South, Dept. of Chemistry and Mathematics, Fort Myers, FL 33965. *Increased Adaptivity in Smoothed Polynomial Histograms with Application to Massive and Pre-Binned Datasets.*

Smoothed polynomial histograms attain their computational efficiency by generating nonparametric density estimators that attempt to match bin moments. This work improves upon the smoothed polynomial histogram via quadratic programming with a roughness penalty and inequality constraints corresponding to confidence intervals for the local sample moments. The use of confidence intervals provides increased adaptivity. In addition to density estimation, applications exist in physics in the form of pre-binned data, massive data sets such as internet traffic, and census-type data. Future work will explore the effects of adaptive knot selection and higher-order derivatives in the penalty on the quality of the density estimate. (Received September 20, 2010)

1067-62-1492 **Hasan Hamdan** (hamdanhx@jmu.edu), Harrisonburg, VA 22801, **Ling Xu** (xulx@jmu.edu), Harrisonburg, VA 22801, **Holly Gardner** (hgardner.nola@gmail.com), New Orleans, LA 70122, **Sam Helmich** (sam.helmich@gmail.com), Winona, MN 55988, **Caitlin Steiner*** (steiner.caitlin@gmail.com), Sterling, VA 20164, and **Kevin Stoll** (kevstoll@gmail.com), Norwalk, OH 44857. *Estimating Variance-Mean Mixtures of Normals.*

In this presentation, we will introduce a new method, NVM_UNMIX for estimating the density function of Normal variance-mean mixtures. This new method is a manipulation of the previously developed Normal scale mixture program UNMIX (Hamdan et al., 2005). NVM_UNMIX is designed to model Normal variance-mean mixtures by minimizing the weighted square distance between an empirical density and the theoretical mixture, taking into account any factors that effect the variability of the estimates. This modeling technique is then evaluated using several simulated examples and is compared to the Bayesian approach in a couple of real life situations. It was found, from the simulation that NVM_UNMIX appears to performed with efficiently and precision when modeling well-mixed and partially mixed distributions, which is unique among mixture estimators. Compared to non-informative Bayesian approach, it was also found to accurately model skewness and robustness in the tails of real-life data. (Received September 21, 2010)

1067-62-1657 **Jin Tan*** (jtan21@uic.edu), 2817 S Unon Ave, 1R, Chicago, IL 60616. *On the Comparison of One Stage and Two Stage Selection Procedures in Bayes Approach.* Preliminary report.

Multistage selection procedures, especially two stage selection procedure has been widely considered in literature, but the there is not a lot on its advantage or disadvantage compared to the traditional one stage selection procedure. I will talk about the comparison of one stage selection procedure and two stage procedure in balanced model with cost of sampling. Decision theoretic Bayes approach is utilized to evaluate the posterior risks. Theoretical and simulation results are given for two most widely used distributions, normal distributions with unknown means and binomial distributions with unknown probabilities of success. (Received September 21, 2010)

1067-62-1714 **Justin W Hansen** (jwhansen@uvm.edu), 53 Chase Street, Apartment 2, Burlington, VT 05401, and **Haimeng Zhang*** (hzhang@math.msstate.edu), Allen 430, Mississippi State, MS 39762. *Efficiency of Maximum Partial Likelihood Estimators with Nested Case Control Sampling and Comparisons to Maximum Likelihood Estimators.* Preliminary report.

In making inference on the relation between failure and covariates in Cox regression models, the maximum partial likelihood estimator (MPLE) is put forward. It is always interesting to assess if the proposed estimator used the available information in the efficient manner. In a regular parametric model, the Cramer-Rao variance lower bound provides the smallest possible variance for estimating an unknown parameter. Under regularity, it is well known that the maximum likelihood estimator (MLE) achieves this lower bound and so it is asymptotically efficient.

In this project, we consider the efficiency of the MPLE for nested case-control sampling under the highly stratified situation, where the covariate values are increasingly less dependent upon the past and there is no censoring. Starting through the use of previous information about the efficiency of MLE in covariate situations, we can progress to the unknown sampling efficiency. In particular, through numerical study under the parametric distribution for the failure time, the efficiency of the MPLE is investigated and its performance is compared with the MLE when the sample size is finite. (Received September 21, 2010)

1067-62-1748 **Katherine A Grzesik*** (kgrzesik@oswego.edu), 9409 Elm St., Chadwicks, NY 13319, and **Heather Shappell**, **Michael Donders** and **Chelsea Ross**. *A Poisson Approximation for the Number of kl-Matches I.*

Consider a lecture class with a population N. Suppose a student keeps track of the order of students called upon to answer a question. Each student on the roster has l friends before his/her name and l friends after his/her name. A *kl-match* occurs when two students, who are in each other's list of $2l$ friends or are themselves, are called upon within the k previous questions. Let X_n denote the number of *kl-matches*. The definition of the random variable X_n assumes that each student has a full window of $2l+1$ friends and a full window of k previous questions. This scenario is built off of Burkhardt, Godbole, and Prengman's (1994) paper about the distribution of k-matches. The distribution of X_n, in an equiprobable case, is approximated by a Poisson random variable if $lk^2 = o(N)$. In the non-equiprobable case, the distribution is also approximately Poisson. A coupling could decrease the amount of total distance variation incurred in the Poisson approximation. (Received September 21, 2010)

1067-62-1774 **Michael Donders*** (msd002@mcdaniel.edu), 670 East 7th Street, Brooklyn, NY 11218, and **Katherine Grzesik**, **Chelsea Ross** and **Heather Shappell**. *A Poisson Approximation for the Number of kl-Matches II.* Preliminary report.

Consider two ordered lists A and B. Let $A =< a_1, a_2, a_3, \ldots, a_j >$ such that all elements of A are distinct, and let $B =< b_1, b_2, b_3, \ldots, b_k >$ where b_i is a random element of A, allowing for repetition. The question "How often will there be two values, say x and y, that are 'close' in A also be 'close' in B" has been discussed. Now we consider the case in which A or B is an n-dimensional list, that is to say each element of our order list is itself an ordered list. (Received September 21, 2010)

1067-62-1875 **Chengyu Liu*** (cliu59@wisc.edu), 101 Conover, 1650 Kronshage Dr., Madison, WI 53706, and **Wei Pan**, Peking, Peking. *Fair Regulation and Calculation Of Scores In Competitions Involving Judges' assessment.*

Introduction: The goal of our research is to evaluate scoring system in competitions involving judges' assessment using psychological and statistical approaches and thus to improve the system used in competitions. The data from real competitions and situations will be used to find the loopholes in the old scoring system and methods will be design to fix the loopholes. The outcome improving methods will be evaluated for efficiency and tested if theoretically efficient.

Preliminary Results: Present Candidate Solutions: 1 Use a new kind of statistic to describe the data center. 2 Comparison of all the score given by one judge, and analyze the pattern of score change. 3 Eliminate the bias by psychology analysis and orthogonal table analysis of bias.

Discussion and Future Work: All 3 methods we developed now all have their advantages and disadvantages, the second one is the most feasible one in all 3 of the candidates. The most crucial problems are maximum extraction of information from the data and the balance between data quantity and data collection efficiency. And we plan to gather the view and experience of more people who work in music and art areas to help us to get better solutions. (Received September 22, 2010)

1067-62-2185 **Kumer Pial Das*** (kumer.das@lamar.edu), Beaumont, TX 77710, and **Md. Shamim Sarker** (mssarker@my.lamar.edu), Beaumont, TX 77710. *The Joint Distribution of Surplus Immediately Before Ruin And The Deficit at Ruin Under Interest Force.* Preliminary report.

In this study a compound Poisson risk model with a constant interest force has been considered. A numerical method has been developed to efficiently compute the joint distribution of surplus before and the deficit at ruin under interest force. Programming language R has been used to obtain the numerical approximation of the joint distribution in case of different claim size distributions. (Received September 22, 2010)

1067-62-2280 **Michelle York*** (myork1@student.clayton.edu), 2000 Clayton State Blvd, Morrow, GA 30236, **Catherine Matos** (cmatos@clayton.edu), 2000 Clayton State Blvd, Morrow, GA 30236, and **Mary Hudachek-Buswell** (MaryHudachek-Buswell@clayton.edu), 2000 Clayton State Blvd, Morrow, GA 30236. *Supporting Women in STEM fields: The Wi^2STEM Club"s Impact on Student Members at Clayton State University.* Preliminary report.

The Women Interested in Science, Technology, Engineering and Mathematics (Wi^2STEM) club at Clayton State University (CSU) was formed two 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 and other activities. Wi^2STEM 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.

The undergraduate presenter will report on the 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 Wi^2STEM member GPAs with the general CSU STEM student 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. (Received September 22, 2010)

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1067-65-80 **Zhuojun Magnant*** (ztang4@emory.edu), 858 Willivee Dr., Decatur, GA 30033, and **Eldad Haber**. *Finding the optimal L2 regularization.*

In various areas such as medical imaging and geophysics, inverse problems frequently arise. Since many of these problems are ill-posed, solutions cannot be obtained directly from the observed data. Hence, additional information needs to be added to the problem by regularization techniques. In this work, we introduce optimal design techniques and several optimality criteria will be proposed to find the best possible L2 regularization matrix. Certain sparsity constraints will be added to the regularization matrix in order to reduce the computational cost and the solution will be obtained through an optimization approach. Numerical experiments will include a 1D magnetotelluric example and MRI reconstructions as well. (Received July 19, 2010)

1067-65-87 **Jintao Cui*** (cui@math.lsu.edu), 3650 Nicholson Drive, Apt. 2146, Baton Rouge, LA 70802. *Hodge Decomposition and Maxwell's Equations.*

In this talk we propose a new numerical approach for two-dimensional Maxwell's equations that is based on the Hodge decomposition for divergence-free vector fields. An approximate solution for Maxwell's equations is obtained by solving standard second order scalar elliptic boundary value problems. We illustrate this new approach by a P_1 finite element method. We will present both theoretical and numerical results. This is joint work with Susanne C. Brenner, Zhe Nan and Li-yeng Sung. (Received July 21, 2010)

1067-65-226 **Sergei Pereverzyev*** (sergei.pereverzyev@oeaw.ac.at), Prof. Dr. Sergei Pereverzyev, Johann Radon Institute (RICAM), Altenbergerstrasse, 69, 4040 Linz, Austria, **Sivananthan Sampath** (sivananthan.sampath@oeaw.ac.at), Dr. Sivananthan Sampath, Johann Radon Institute (RICAM), Altenbergerstrasse, 69, 4040 Linz, Austria, and **Valeriya Naumova** (valeriya.naumova@oeaw.ac.at), Valeriya Naumova, Johann Radon Institute (RICAM), Altenbergerstrasse, 69, 4040 Linz, Austria. *On the multi-parameter regularization for ill-posed problems.*

In the regularization theory for ill-posed problems mainly schemes with a single regularization parameter have been studied. Among these methods, probably the most famous one is the Tikhonov regularization method, in which a regularized solution is obtained by minimizing a quadratic functional with a penalty term. But even in this scheme, we are, in fact, dealing with a multi-parameter regularization, since not only regularization parameter, but also a penalization operator should be chosen properly. In the talk we are going to discuss several approaches to the multi-parameter regularization and present recent results in this direction. (Received August 10, 2010)

1067-65-252 **Dylan M Copeland*** (copeland@math.tamu.edu), Institute for Scientific Computation, Texas A&M University, College Station, TX 77843, and **Ulrich Langer**. *Domain Decomposition Solvers for Nonlinear Multiharmonic Finite Element Equations.*

In many practical applications, e.g. in computational electromagnetics, a time-harmonic excitation allows one to avoid expensive time-stepping schemes by switching to the frequency domain and solving a simple elliptic equation for the amplitude. This is possible for linear problems, but not for nonlinear problems. However, due to the periodicity of the solution, we can expand the solution in a Fourier series. Truncating this Fourier series and approximating the Fourier coefficients by finite elements, we arrive at a large-scale coupled nonlinear system for determining the finite element approximation to the Fourier coefficients. The construction of fast solvers for such systems is very crucial for the efficiency of the multiharmonic approach. In this talk, we construct and analyze nearly optimal solvers for the Jacobi systems arising from the Newton linearization of the large-scale coupled nonlinear system. Numerical experiments with parallel computations demonstrate the performance of the solver. (Received August 13, 2010)

1067-65-308 **Doreen Fischer*** (fischer@mathematik.uni-siegen.de). *Recovering a Tomographic Model of the Earth by Sparse Regularization of a Joint Inversion of Gravitational Data and Normal Mode Anomalies.*

To recover the density of the Earth we invert Newton's gravitational potential. It is a well-known fact that this problem is ill-posed. Moreover, it even becomes exponentially ill-posed if we use satellite data as input. Thus, we need to develop a regularization method.

We applied the idea of a matching pursuit to recover a solution stepwise. At step $n+1$, the basis function d_{n+1} and the weight α_{n+1} are selected to best match the data structure.

One big advantage of this method is that all kinds of different basis functions can be taken into account to improve the model stepwise and the sparsity of the solution can be controlled directly. Moreover, this new

approach generates models with a resolution that is adapted to the data density and the detail density of the solution.
We applied our method to reconstruct the density distribution of the Earth and the seasonal changes in the area of the Amazon. However, from gravitational data alone it is only possible to recover the harmonic part of the density. To get information about the anharmonic part as well, we need to be able to include other data types, e.g. normal mode anomalies, and perform a joint inversion which is a main feature of the developed method.

Berkel, Fischer, Michel (GEM 2010) (Received August 19, 2010)

1067-65-354 **Andrei Bourchtein*** (bourchtein@gmail.com), Rua Anchieta 4715 bloco K, ap.304, Pelotas, 96015-420, Brazil, and **Ludmila Bourchtein** (bourchtein@terra.com.br), Rua Anchieta 4715 bloco K, ap.304, Pelotas, 96015-420, Brazil. *On correct boundary conditions in numerical schemes for the shallow water equations.*

In this study we consider a non-physical growth of numerical solutions to the shallow water equations, which can be observed in the cases when the choice of the boundary conditions appears to be physically justifiable and the initial-boundary value problem for the primitive differential system is well posed. This growth can happen in both conditionally and absolutely stable numerical schemes and it can not be eliminated by reducing the time step. Since the corresponding numerical problem with the periodic boundary conditions is conditionally or absolutely stable, such instability is related to the specific non-periodic boundary conditions. The analytical study of such behavior is performed for a simple model of one-dimensional gravity waves, which allows us to reveal the causes of such instability. Based on the performed analysis and numerical experiments, some recommendations for choosing the boundary conditions are given to avoid the non-physical behavior of numerical solutions. (Received August 26, 2010)

1067-65-363 **Yingda Cheng*** (ycheng@math.utexas.edu), Dept of Math and ICES, Univeristy of Texas at Austin, Austin, TX 78712, **Irene M Gamba** (gamba@math.utexas.edu), Dept of Math and ICES, University of Texas at Austin, Austin, TX 78712, and **Phillip J Morrison** (morrison@physics.utexas.edu), The University of Texas at Austin, Institute for Fusion Studies, Austin, TX 78712. *Discontinuous Galerkin Schemes for Vlasov-Poisson Systems.*

In this talk, we will present some preliminary results on the discontinuous Galerkin (DG) schemes for Vlasov-Poisson (VP) systems in plasma physics. Firstly we will investigate and rigourously study the recurrence phenomenon which results from finite resolution in the phase space. Then we will provide numerical tests on the linear landau damping problems. Finally we investigate the performance of various DG schemes for the nonlinear VP systems. In particular, we will look into the physical invariance, BGK modes and trapping scaling. Some dicussion related to the quasilinear theory will be provided. We will also mention some ongoing work in the simulation of Vlasov-Maxwell systems. The emphasis of the talk will be both the design of numerical schemes and the physics embedded in the simulation. (Received August 27, 2010)

1067-65-382 **Brittany D. Froese*** (bdf1@sfu.ca) and **Adam M. Oberman**. *Finite Difference Methods for Viscosity Solutions of the Monge-Ampère Equation.*

The elliptic Monge-Ampère equation is a fully nonlinear Partial Differential Equation that originated in geometric surface theory and has been applied in dynamic meteorology, elasticity, geometric optics, image processing and image registration. Solutions may be singular, in which case standard numerical approaches can fail. Novel solution methods are required for stability and convergence to weak solutions.

In this talk we describe a monotone finite difference discretization for the Monge-Ampère equation, which provably converges to the weak (viscosity) solution. Solution accuracy is improved by using a hybrid discretization that selects either the convergent monotone discretization or a more accurate finite difference discretization in different regions of the computational domain. This discretization is determined *a priori* using regularity results. The resulting nonlinear equations are then solved by Newton's method.

Computational results in two and three dimensions validate the claims of both accuracy and solution speed. (Received August 30, 2010)

1067-65-396 **Lauren A. Ferguson*** (lafergus@tamu.edu), Department of Mathematics, Texas A&M University, Mailstop 3368, College Station, TX 77843-3368. *A Numerical Model of Fracture using Curvature Dependent Surface Tension.*

The classical theory of linear elastic fracture mechanics for a static crack in an infinite linear elastic body has two significant defects: it predicts unbounded crack-tip stresses and an elliptical crack opening profile. A new model of fracture based on extending continuum mechanics to the nanoscale corrects these anomalous effects, predicting finite crack-tip stresses and a cusp-like opening profile. The fundamental attribute of this model is its incorporation of long-range intermolecular forces and surface excess properties, one of which is surface tension computed as a function of curvature. We describe the method for determining the surface tension constants that guarantee bounded crack-tip stresses. We also discuss strategies for developing and implementing the resulting numerical model of fracture. (Received August 31, 2010)

1067-65-403 **Xiangxiong Zhang*** (zhangxx@dam.brown.edu). *Maximum-principle-satisfying and positivity-preserving high order discontinuous Galerkin and finite volume schemes for conservation laws.*

We construct uniformly high order accurate discontinuous Galerkin (DG) and finite volume (FV) schemes satisfying a strict maximum principle for scalar conservation laws and passive convection in incompressible flows, and positivity preserving for density and pressure for compressible Euler equations. A general framework (for arbitrary order of accuracy) is established to construct a limiter for the DG or FV method with first order Euler forward time discretization solving one dimensional scalar conservation laws. Strong stability preserving (SSP) high order time discretizations will keep the maximum principle and make the scheme uniformly high order in space and time. It is straightforward to extend the method to two and higher dimensions. The same limiter can be shown to preserve the maximum principle for the DG or FV scheme solving two-dimensional incompressible Euler equations in the vorticity stream-function formulation, or any passive convection equation with an incompressible velocity field. A suitable generalization results in a high order DG or FV scheme satisfying positivity preserving property for density and pressure for compressible Euler equations and positivity preserving for water height for shallow water equations. Numerical tests will be shown. (Received September 01, 2010)

1067-65-448 **Mary F. Wheeler** and **Guangri Xue*** (gxue@ices.utexas.edu), The University of Texas at Austin, ACE 5.318, ICES, 201 E 24th Street, Austin, TX 78712, and **Ivan Yotov**. *A multipoint flux mixed finite element method on distorted quadrilaterals and hexahedra.*

We develop a new mixed finite element method for elliptic problems on general quadrilateral and hexahedral grids that reduces to a cell-centered finite difference scheme. A special non-symmetric quadrature rule is employed that yields a positive definite cell-centered system for the pressure by eliminating local velocities. The method is shown to be accurate on highly distorted rough quadrilateral and hexahedral grids, including hexahedra with non-planar faces. Theoretical and numerical results indicate first-order convergence for the pressure and face fluxes. (Received September 03, 2010)

1067-65-457 **Zhimin Zhang*** (zzhang@math.wayne.edu), 656 West Kirby, Detroit, MI 48202, and **Nairat Kanyamee**. *Spectral Collocation/p-Version Finite Element Methods for Hamiltonian Dynamical Systems.*

We carry out a systematical study of spectral Galerkin methods (or p-version finite element methods) and spectral collocation methods in numerically solving the Hamiltonian dynamical systems. Different strategies including Legendre-Lobatto collocation, Chebyshev-Lobatto collocation, spectral Galerkin/p-version, are discussed and compared, especially with symplectic methods. Numerical tests on some benchmark nonlinear problems are provided. (Received September 04, 2010)

1067-65-517 **Bernd Hofmann*** (hofmannb@mathematik.tu-chemnitz.de), Chemnitz University of Technology, Department of Mathematics, Reichenhainer Str. 39/41, 09107 Chemnitz, Germany. *Four kinds of expressing solution smoothness and their consequences for ill-posed problems.*

In the analysis of ill-posed inverse problems the impact of solution smoothness on accuracy and convergence rates plays an important role. For linear ill-posed operator equations in Hilbert spaces and with focus on the linear regularization schema we will establish relations between the different kinds of measuring solution smoothness in a point-wise or integral manner. In particular we discuss the interplay of distribution functions, profile functions that express the regularization error, index functions generating source conditions, and distance functions associated with benchmark source conditions. Examples exhibit typical situations in applications with compact and non-compact forward operators. This is joint work with Peter Mathé (Berlin) and Jens Flemming (Chemnitz). (Received September 08, 2010)

1067-65-612 **R. Corban Harwood*** (rharwood@math.wsu.edu), Department of Mathematics, PO Box 643113, Neill 103, Pullman, WA 99164-3113, and **Likun K. Zhang**, **T. Zaki Jubery**, **Greg M. Vogel**, **W. Gitau Munge**, **Joe J. Theisen** and **V. S. Manoranjan**. *Oscillation-Free Operator Splitting Method for Semilinear Diffusion Equations.*

An oscillation-free splitting method is presented for the solution of semilinear diffusion equations. Instead of numerically solving the equation as a whole, an operator splitting technique is applied to the partial differential equation, where the linear diffusion and the nonlinear remainder portions are solved separately. A weighted Euler scheme is developed to give an oscillation-free solution to the diffusion portion with second order spatial and temporal accuracy, while the remainder portion is solved exactly for a specific problem. Since oscillations can lead to instabilities in solutions to nonlinear differential equations, this oscillation-free method ensures global stability. To maintain second order global accuracy in both space and time, the solutions of these two portions are combined alternatingly. This accuracy is discussed analytically, by relating it to one utilizing a linearized operator, and verified numerically. (Received September 11, 2010)

1067-65-651 **Olga Stulov*** (olga.stulov@gmail.com), 25 Henry W Dubois, Apt. 20, New Paltz, NY 12561, and **Ian C Johnson**, **Evelyn Sander** and **Thomas Wanner**. *Stability of equilibria in one dimension for diblock copolymer equation.* Preliminary report.

This paper demonstrates the use of the mathematical model for diblock-copolymer equilibria to obtain the solutions of the homogeneous and inhomogeneous equilibria. In order to determine the stability of the system in the time varying solution, the eigenvalues and eigenfunctions were found. The positive eigenvalues represented the unstable directions, thus allowing to study the behavior of the diblock copolymers near the equilibria. While the homogeneous equilibrium solution was found analytically, the solution of the inhomogeneous equilibrium had to be solved for numerically. The various sets of the solutions of the model were found by means of the software AUTO. These sets were then embedded in MATLAB to solve for the eigenvalues and eigenfunctions of the system. In addition, the latter were plotted for the interpretation of the results. For simplicity the model was studied in one dimension. (Received September 12, 2010)

1067-65-652 **Ahmed A. Naga*** (anaga@math.wayne.edu), 1703 Star Batt Dr., Rochester Hills, MI 48309, and **Zhimin Zhang** (zzhang@math.wayne.edu), Department of Mahtematics, Wayne State Unversity, Detroit, MI 48202. *Applications of recovery techniques in finite element methods.*

Recovery techniques are postprocessing algorithms that reconstruct the numerical solution or its gradient. The real interest in using them boosted after the work of Zienkiewicz-Zhu in which they used gradient recovery to produce asymptotically exact error estimators. Such idea gained lots of interest in the scientific computing community. The idea is to produce a more accurate continuous gradient using the gradient of the finite element solution in what is now known as Superconvergent Patch Recovery (SPR). This raised the following question: why not the function values? Answering this question led us to the Polynomial Preserving Recovery (PPR) method in which the gradient is recovered using the finite element solution itself. Babuska, et al, showed that the ZZ error estimator, based on SPR, was the most 'robust" error estimator among the existing error estimators. The ZZ error estimator based on PPR was found to be at least as robust as the ZZ-SPR estimator. Recently, recovery techniques found their way in eigenvalue problems and in recovering second order derivatives. For example, it is possible to use the recovered gradient and/or recovered functions to enhance the computed eigenvalues. The "recovered" eigenvalues ultra-converges to the exact ones. (Received September 12, 2010)

1067-65-827 **Huiqing Zhu*** (Huiqing.Zhu@usm.edu), 118 College Drive, #5045, Hattiesburg, MS 39401, and **Zhimin Zhang** (zzhang@math.wayne.edu), 656 W. Kirby, FAB 1131, Detroit, MI 48202. *Local Error Estimates of the LDG Method for One-Dimensional Singularly Perturbed Convection-diffusion Equations.*

The local discontinuous Galerkin method (LDG) is applied to one-dimensional singularly perturbed convection-diffusion equations, which exhibit a boundary layer near the outflow boundary. Local error estimates are established on quasi-uniform meshes with maximum mesh size h. On a subdomain with $O(h \ln(1/h))$ distance away from the outflow boundary, the L^2 errors of the LDG approximations to the solution and its derivative converge at an optimal rate, which is also uniformly valid in terms of the singularly perturbed parameter. The numerical experiments illustrate that the rate of convergence is sharp. Comparison studies are made between the LDG method and the streamline-diffusion finite element method. (Received September 15, 2010)

1067-65-828 **Mary Fanett Wheeler*** (mfw@ices.utexas.edu), The University of Texas at Austin, 201 East 24th Street, Aistom, TX 78712. *Role of Computational Science in Protecting the Environment: Geological Storage of CO2.*

Simulation of field-scale CO2 sequestration (which is defined as the capture, separation and long-term storage of CO2 for environmental purposes) has gained significant importance in recent times. Here we discuss mathematical and computational formulations for describing reservoir characterization and evaluation of long term CO2 storage in saline aquifers as well as current computational capabilities and challenges. (Received September 15, 2010)

1067-65-832 **Michael J. Neilan*** (neilan@math.lsu.edu), Mathematics, Center for Computation and Technology, Louisiana State University, Baton Rouge, LA 70803. *A unified approach to construct and analyze finite element methods for the Monge-Ampère equation.*

The Monge-Ampère equation is a fully nonlinear second order PDE that arises in various applications such as differential geometry, meteorology, reflector design, economics, and optimal transport. Yet despite its prevalence in many application areas, numerical methods for the Monge-Ampère equation is still in its infancy. In this talk, I will discuss a unified approach to construct and analyze various finite element methods for the Monge-Ampère equation. First, I will show that a key feature to develop convergent discretizations is to construct schemes with a stable linearization. I will then describe a methodology to construct finite elements that inherit this trait and provide two examples: C^0 finite element methods and discontinuous Galerkin methods. I will then briefly show how to prove the well-posedness of such methods as well as derive optimal order error estimates. (Received September 16, 2010)

1067-65-834 **Yanzhao Cao*** (yzc0009@auburn.edu), Dept of Math & Stat, Auburn University, Auburn, AL 36849. *Hydraulic Conductivity Inverse Formulation for the Groundwater Flow Problem with Variable Density.*

A mathematical optimal control method is developed to identify the hydraulic conductivity distribution in a density dependent flow field. By using the variation method to the nonlinearly coupled flow and transport equations for the density-dependent flow, we deduce the adjoint partial differential equations for the density-dependent equations used for the saline aquifer water flow. The adjoint equations are numerical solved in this study through a finite difference method and then used to identify the hydraulic conductivity distribution through an optimal control problem. To demonstrate the effectiveness of the optimal control method, we conduct two numerical experiments as case studies. The results indicate that by using hydraulic head measurement data, we can accurately identify conductivity distributions in a saline water aquifer flow system. (Received September 15, 2010)

1067-65-939 **Yan Li***, Institute for Mathematics and its Application, University of Minnesota, 114 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455, and **Chen Yuguang**, 6001 Bollinger Canyon Road, D2092, San Ramon, CA 94583. *Upscaling methods of flow and transport in heterogeneous porous media.*

Flow and transport are the two main mechanisms in subsurface flow. Due to the very high resolution involved, direct numerical simulation of subsurface flow is usually not feasible. Therefore upscaling procedures are often applied to coarsen the highly detailed models to scales that are suitable for flow simulation.

In this talk, I will discuss a local-global two-phase upscaling method for flow and transport in heterogeneous reservoirs. The upscaling of two-phase flow parameters is challenging, due to their strong dependency on global flow effects. The local-global two-phase upscaling directly incorporates global coarse-scale two-phase solutions into local two-phase upscaling calculations. It effectively captures the impact of global flow, while avoiding global two-phase fine-scale simulations. The local boundary conditions are updated with time-dependent coarse-scale solutions. It therefore captures the global flow effects both spatially and temporally. The method is applied to permeability distributions with various correlation lengths and for different fluid-mobility ratios. Numerical results show that it consistently improves upon existing two-phase upscaling methods and provides accurate coarse-scale solutions for both flow and transport. (Received September 16, 2010)

1067-65-1016 **Andrew T. Barker*** (andrewb@math.lsu.edu), Department of Mathematics, Lousiana State University, Baton Rouge, LA 70803-4918, and **Susanne C. Brenner** and **Li-Yeng Sung**. *Additive Schwarz preconditioners for the local discontinuous Galerkin method.*

The local discontinuous Galerkin method is an attractive discretization because it allows for easy local mesh refinement and adaptivity and satisfies optimal error estimates, but does not require the tuning of a penalty parameter. We develop and analyze two level additive Schwarz preconditioners for the LDG discretization, considering different coarse spaces and intergrid transfer operators, and show that the condition number of the preconditioned operator is bounded independent of the number of subdomains and the discretization size. Finally, we present numerical results illustrating the real-world performance and parallel scalability of the method. (Received September 17, 2010)

1067-65-1061 **Thomas F. Russell*** (trussell@nsf.gov), National Science Foundation, Office of Integrative Activities, 4201 Wilson Blvd., Room 1270, Arlington, VA 22230. *Locally mass-conservative Eulerian-Lagrangian methods for multiphase multicomponent transport.*

Secondary and tertiary recovery of hydrocarbons and contaminant transport in groundwater are among the subsurface flow processes that are frequently advection-dominated. These geomathematical settings lead to efforts to incorporate Lagrangian techniques into numerical schemes. Compared with purely Eulerian schemes, when Eulerian-Lagrangian methods (ELMs) work well, ELMs can obtain more accurate results on coarser grids and with larger time steps. In particular, CFL limitations, numerical dispersion, and non-physical oscillations can be avoided. For nonlinear multiphase transport, a key to formulating conservative ELMs is the physical insight that emerges from an adjoint system, whose Lagrangian characteristics represent mass movement rather than wave propagation. The talk will formulate ELMs for multiphase multicomponent transport and will present some recent results. (Received September 17, 2010)

1067-65-1081 **Samuel N. Jator*** (jators@apsu.edu), 601 College Street, Austin Peay State University, Clarksville, TN 37044. *Numerical solution for parabolic equations by a hybrid method.*

We propose a hybrid method for the numerical solution of parabolic partial differential equations (PDEs) which is facilitated by the method of lines technique; where we discretize the space derivatives in such a way that the resulting system of ordinary differential equations is stable. We then discretize the time derivatives by the hybrid method. The method is self-starting, of fifth order in time and A-stable. The method is tested on some numerical examples. (Received September 18, 2010)

1067-65-1099 **Minah Oh*** (ohmx@jmu.edu), Dept. of Mathematics and Statistics, James Madison University, 305 Roop Hall, MSC 1911, Harrisonburg, VA 22807, and **Jay Gopalakrishnan**, Department of Mathematics, University of Florida, FL 32611. *Commuting Smoothed Projectors in Weighted Spaces.*

We construct smoothed projectors in weighted Sobolev spaces that arise naturally when modeling electromagnetic problems under axial symmetry and performing dimension reduction via cylindrical coordinates. The advantages of these projectors are that they are continuous in the weighted L^2-norm, and that they also preserve the commuting diagram properties. These operators are then used to prove a quasi-optimality result of the edge finite element approximation when applied to the axisymmetric Maxwell equations on bounded Lipschitz domains. (Received September 18, 2010)

1067-65-1181 **James M Rath*** (ratjamm@alum.mit.edu), PO Box 7923, Austin, TX 78713. *Approximate worm blankets using segmented worms.*

A method is proposed for computing approximate blankets for Moser's worm problem. Candidate blankets have been found that are smaller than any known blanket. The method discretizes placement maps, functions that describe where a worm fits on a particular blanket. The method can be extended to constructing worm houses in three or more dimensions. (Received September 19, 2010)

1067-65-1197 **Thomas Fidler*** (thomas.fidler@univie.ac.at), Computational Science Center, Nordbergstrasse 15, 1090 Vienna, 1090 Vienna, Austria. *Shape Reconstruction based on Integral Invariants: Theory and Applications.*

In this talk we introduce integral invariants, which can be seen as the canonical counterpart of the well known differential invariants. We highlight the advantages of the integral representation and focus on the mathematical theoretical challenges encountered in the problem of shape reconstruction. As a reasonable application we consider the problem of reconstructing a shape from its Radon transform in limited directions. Since the set of directions where data is available is insufficient for an exact reconstruction we have to incorporate some a-priori information to stabilize the reconstruction process. We formulate the problem as a minimization problem and propose to use a regularization functional based on integral invariants which encodes the a-priori information, e.g. curvature, in a stable way. (Received September 20, 2010)

1067-65-1199 **Volker Michel*** (michel@mathematik.uni-siegen.de), Geomathematics Group, Emmy-Noether-Campus, University of Siegen, 57076 Siegen, Germany. *Sparse Regularization of Geophysical Inverse Problems by a Greedy Algorithm.*

Localized methods for the processing of geophysical and geodetic signals including inverse problems have been developed for several decades. These spline and wavelet methods use "hat-like" basis functions which are centered around certain points of the sphere or the ball. However, the choice of the grid for the centers is not ideal, yet. Wavelet methods require the use of a quadrature grid, whereas the spline method uses a grid which corresponds to the data grid. Moreover, the calculation of the spline is connected to a system of linear equations, which limits the resolution due to the size of the associated dense matrix.

Due to the increasing size of data which is necessary to improve current models of the Earth's interior, these approaches have to be further enhanced. It will be shown that a more flexible choice of the centers of the basis functions can be achieved by an iterative method, which is motivated by dictionary-based Euclidean methods called greedy algorithm and matching pursuit. The centers are now primarily chosen where locally a high content of detail information is hidden in the solution. Moreover, much more basis functions can be used than before, which yields a significantly increased resolution. (Received September 20, 2010)

1067-65-1212 **Noel J Walkington*** (noelw@andrew.cmu.edu), 5000 Forbes Ave, Pittsburgh, PA 15213. *Modeling Fluids with Microstructure.*

Macroscopic models of complex fluids typically couple the momentum equation to an equation governing the evolution of the microstructure. Examples include liquid crystals, fluids containing elastic particles, and polymer fluids. This talk will focus on the development and analysis of numerical schemes which inherit the delicate balance between inertia, transport, and dissipation present in these models. The intimate connection between these physical quantities and mathematical properties, such as stability and compactness of solutions, will be highlighted. (Received September 20, 2010)

1067-65-1302 **J. B. Collins*** (jbcolli2@gmail.com), 3133 J Aileen Dr., Raleigh, NC 27606. *A new junction model for gas flow through a splitting pipe.*

Computation of transport over complicated network domains can be simplified using network models. These models involve one-dimensional transport equations, coupled with junction models for the multi-dimensional portions of the network. Junction models can be a large source of error in network problems. In this work, we consider gas flow through a pipe network. A junction model based on numerical data is derived and compared to known junction models. The accuracy of the model with two-dimensional data is examined and the effect of junction geometry on this accuracy is shown. (Received September 20, 2010)

1067-65-1599 **Weifeng Zhi*** (wzhi@ms.uky.edu), 715 Patterson Office Tower, Lexington, KY 40508. *The Alignment of Manifold Sections for Manifold Learning.* Preliminary report.

The alignment algorithm of Zha and Zhang for nonlinear manifold learning is recovering the low-dimensional parameterization from high-dimensional data sets. It constructs an alignment matrix from the local coordinates sections. We can obtain the global coordinates from the null space of this alignment matrix. The first nonzero eigenvalue of the matrix plays a very important role in the computation. The paper of Li, Li and Ye in 2007 gives a lower bound for the smallest nonzero eigenvalue. We will present some properties for this algorithm. Furthermore, we will show some applications to compare this algorithm with other nonlinear manifold learning algorithms. (Received September 21, 2010)

1067-65-1681 **Haijun Yu*** (hyu@purdue.edu), 150 N. University Street, West Lafayette, IN 47907, and **Jie Shen** (shen7@purdue.edu), 150 N. University Street, West Lafayette, IN 47907. *Fast Spectral Sparse Grid Methods for High Dimensional Non-periodic Problems.*

Based on 1-dimensional fast Chebyshev transform on the Chebyshev-Gauss-Lobatto grid points, we built a fast Chebyshev transform on high dimensional sparse grids(spFCT). This algorithm is further used on function interpolation and solving high-dimensional PDEs with non-periodic boundary conditions. Numerical examples are presented to show the efficiency of the proposed methods in solving elliptic problems. (Received September 21, 2010)

1067-65-1771 **Bernardo Cockburn**, **Bo Dong*** (bdong@math.drexel.edu), **Johnny Guzman**, **Marco Restelli** and **Riccardo Sacco**. *A Hybridizable Discontinuous Galerkin Method for Steady-State Convection-Diffusion-Reaction Problems.*

we propose a novel discontinuous Galerkin method for convection-diffusion-reaction problems, characterized by three main properties. The first is that the method is hybridizable; this renders it efficiently implementable and competitive with the main existing methods for these problems. The second is that, when the method uses polynomial approximations of the same degree for both the total flux and the scalar variable, optimal convergence properties are obtained for both variables; this is in sharp contrast with all other discontinuous methods for this problem. The third is that the method exhibits superconvergence properties of the approximation to the scalar variable; this allows us to postprocess the approximation in an element-by-element fashion to obtain another approximation to the scalar variable which converges faster than the original one. (Received September 21, 2010)

1067-65-1797 **Ben Niu*** (nben@iit.edu), 575 W. Madison Street, Apt 3004, Chicago, IL 60661, and **Fred J Hickernell**, **Klaus Ritter** and **Thomas Müller-Gronbach**. *Multi-level Algorithms for Infinite-dimensional Integration on $\mathbb{R}^{\mathbb{N}}$.*

Pricing a path-dependent financial derivative, such as an Asian option, requires the computation of $E(g(B))$, the expectation of a payoff function g, that depends on a Brownian motion B. Employing a standard series expansion of B the latter problem is equivalent to the computation of the expectation of a function of the corresponding i.i.d. sequence of random coefficients. This motivates the construction and the analysis of algorithms for numerical integration with respect to a product probability measure on the sequence space $\mathbb{R}^{\mathbb{N}}$. The class of integrands studied in this paper is the unit ball in a reproducing kernel Hilbert space obtained by superposition of weighted tensor product spaces of functions of finitely many variables. Combining tractability results for high-dimensional integration with the multi-level technique we obtain new algorithms for infinite-dimensional integration. These deterministic multi-level algorithms use variable subspace sampling and they are superior to any deterministic algorithm based on fixed subspace sampling with respect to the respective worst case error. Numerical experiments will be implemented. (Received September 21, 2010)

1067-65-1809 **Sunyoung Bu*** (agatha@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250, Chapel hill, NC 27514, and **Jingfang Huang**, **Treavor H Boyer** and **Cass T Miller**. *An Evaluation of Solution Algorithms and Numerical Approximation Methods for Modeling an Ion Exchange Process.*

In this work, we discuss the modeling and numerical simulations of the dissolved organic carbon (DOC) removal process in water treatment studies. We first introduce a new age-averaged model (AAM) that averages all ion exchange particle ages for a given size particle to avoid the expensive Monte-Carlo simulation associated with previous modeling applications. To approximate both the original Monte Carlo algorithm and the new AAM for this two-scale problem, we introduce a scheme using an integral equation based Krylov deferred correction (KDC) method and a fast elliptic solver (FES) for the resulting elliptic equations. Numerical results are presented to validate the new AAM algorithm, which is shown to be more computationally efficient than the original Monte Carlo algorithm. We also demonstrate that the higher-order KDC scheme is more efficient than the traditional finite element solution approach and this advantage becomes increasingly important as the accuracy of the solution desired increases. We also discuss issues of smoothness, which affect the efficiency of the KDC-FES approach, and outline additional algorithmic changes that would further improve the efficiency of these developing methods for a wide range of applications. (Received September 21, 2010)

1067-65-1837 **Robert D French*** (roberto.frances@gmail.com), 1351 Avondale Drive, Apt B15, Clarksville, TN 37043, **Casey L McKnight** (mcknightcasey@gmail.com), 1351 Avondale Drive, Apt B15, Clarksville, TN 37043, and **Ben Ntatin** (ntatinb@apsu.edu). *A Simple Parallel Implementation of the Finite Element Method Using Linear Geometries.*

The Finite Element Method is a technique for numerically solving partial differential equations. The fundamental idea is that a continuous solution to the governing PDE modeling a physical system can be approximated by subdividing the domain into a set of geometrical elements, which are triangles for a two-dimensional domain. We then approximate the solution at the nodal points. We discuss some geometrical aspects of the finite element method and present a parallel computing package for solving two-dimensional, second order, linear PDEs. To demonstrate the effectiveness of this parallel computing technique, we treat the convection-diffusion-reaction equation at a very fine precision, and show improvements in both time and mesh size. (Received September 22, 2010)

1067-65-1904 **Valeria Simoncini** (valeria@dm.unibo.it), Dipartimento di Matematica, Univeristà di Bologna, Piazza di Porta S. Donato, 5, I-40127 Bologna, Italy, and **Daniel B Szyld*** (szyld@temple.edu), Temple University, Department of Mathematics (038-16), 1805 N Broad Street, Philadelphia, PA 19122. *Superlinear convergence of MINRES.*

We show quantitative bounds for the superlinear convergence of the MINRES method of Paige and Saunders [*SIAM J. Numer. Anal.*, 1975] for the solution of sparse linear systems $Ax = b$, with A symmetric and indefinite. It is shown that the superlinear convergence is observed as soon as the harmonic Ritz values approximate well the extreme eigenvalues of A, i.e., either those closest to zero or farthest from zero. (Received September 22, 2010)

1067-65-1920 **Jangwoon (Leo) Lee*** (llee3@umw.edu), Department of Mathematics, University of Mary Washington, 1301 College Avenue, Fredericksburg, VA 22401, and **L. S. Hou** and **H. Manouzi**. *Finite Element Approximations of Stochastic Optimal Control Problems Constrained by Stochastic Elliptic PDEs.*

In this paper, we study stochastic optimal control problems constrained by stochastic elliptic PDEs. The control objective is to minimize the expectation of a cost functional, and the control is of the deterministic, distributed type. Mathematically, we prove the existence of an optimal solution; we establish the validity of the Lagrange multiplier rule to obtain the stochastic optimality system of equations; we represent the input data in terms of their Karhunen-Loeve expansions and deduce the deterministic optimality system of equations. Computationally, we find finite element approximations to the optimality system and its error through the discretizations of the random parameter space and the spatial space. (Received September 22, 2010)

1067-65-2025 **Beatrice Riviere*** (riviere@rice.edu), CAAM department, 6100 Main Street, MS-134, Houston, TX 77005. *Weak and numerical solutions for coupled Navier-Stokes, Darcy and transport equations.*

The coupling of porous media flow with free flow arises in many applications including the industrial filtration problems and the environmental problems of contaminated aquifers through rivers. In this multiphysics couplings, the free flow is characterized by the Navier-Stokes equations whereas the porous media flow is described by the Darcy equations. Interface conditions such as the Beavers-Joseph-Saffman's law are prescribed at the interface between the two different physical flows. A transport equation satisfied by the contaminant concentration is coupled to the flow problem via the fluid viscosity and the velocity field.

In this work, we first study the well-posedness of weak solutions to the coupled problems. By varying the interface condition for the balance of forces, we construct two weak solutions using a Galerkin approach. Second we define and analyze several numerical schemes based on classical finite element methods and discontinuous Galerkin methods. Convergence of the schemes is also verified numerically. Numerical solutions for non homogeneous porous media are presented. (Received September 22, 2010)

1067-65-2038 **Edward W. Swim*** (edward.swim@shsu.edu) and **Mark P. Adams**. *Stochastic models for heat flow in a cylinder.* Preliminary report.

An immense amount of heat is produced whenever large weapons are fired and may even cause gun barrels to overheat. Over time, this results in damage to the gun barrel, often in the form of cracks and erosion. In order to simulate this process, current methods focus on the use of differential equations that provide a deterministic model for the velocity, pressure, and temperature of gases and residue generated by the burning propellant. However, it is clear that random variations exist within each round fired. This research will investigate the value of including stochastic components within the thermodynamic equations used to simulate heat flow within the cylindrical cannon bore. Under assumptions of cylindrical symmetry, a perfect gas, and constant thermal conductivity, we construct a model based on conservation laws and utilize white noise in order to simulate the random behavior of our heat source. Finite difference methods are then applied to compute solutions to the resulting stochastic boundary value problems. (Received September 22, 2010)

1067-65-2069 **Julie Roy*** (jroy11@mscd.edu), Campus Box 38, P.O. Box 173362, Denver, CO 80217, and **R. Baker Kearfott** (rbk@louisiana.edu), P.O. Box 41010, Lafayette, LA 70504. *A Branch and Bound Process for Singular Global Optimization Problems - Preliminary Explorations.* Preliminary report.

For global optimization problems, it often occurs that there are feasible lines, planes, hyperplanes, or hypersurfaces that have approximately optimal objective function values. For these problems, common deterministic global optimization software may only find one optimal point and not even indicate that other solutions exist, and software with automatically verified complete search algorithms may not complete in a reasonable amount of time. A method for computing rigorous enclosures of sets that contain approximately feasible, approximately optimal solution points for these problems is briefly explained. Preliminary explorations and results for incorporating this method into a general branch and bound process are given. For singular problems, computational time may be significantly less with this modified branch and bound process than with a general branch and bound process. (Received September 22, 2010)

1067-65-2145 **Weimin Han** and **Joseph A Eichholz*** (jeichhol@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242, and **Xiaoliang Cheng** and **Ge Wang**. *A discontinuous Galerkin method for solving a modified Leakeas-Larsen equation.*

Light propagation in biological tissue is governed by the radiative transport equation (RTE). In several current medial imaging modalities the objective is to reconstruct optical parameters of the domain by matching predicted measurements given by solutions of the RTE to observed measurements. Therefore it is important to develop efficient and accurate methods of solving the RTE. In practice, the diffusion equation is used as an approximation to the RTE to reduce computational expense. We propose a new approximation method based on a modification to the Leakeas-Larsen equation. Existence and uniqueness of solutions to this equation is proven, and a discontinuous Galerkin method to solve the problem is developed. (Received September 22, 2010)

1067-65-2210 **Aubrey L Leung*** (leungau@onid.orst.edu), 368 Kidder Hall, c/o Dr. V. A. Bokil, Department of Mathematics, Oregon State University, Corvallis, OR 97331, and **Vrushali A Bokil** (bokilv@math.oregonstate.edu), 368 Kidder Hall, Department of Mathematics, Oregon State University, Corvallis, OR 97331. *A Sequential Operator Splitting Method for Maxwell's Equations in Debye Dispersive Media.* Preliminary report.

We consider Maxwell's equations in dispersive media of Debye type. We present an operator splitting scheme in one dimension that decouples fast and slow moving processes in the problem to develop separate subproblems. We demonstrate that the scheme is unconditionally stable, first order accurate and perform a numerical stability and dispersion analysis. We provide comparisons of our operator splitting method with the Yee finite difference time domain method and demonstrate the advantages of operator splitting. (Received September 22, 2010)

1067-65-2212 **Shelly M McGee*** (mcgee@findlay.edu), 1000 N Main St, Department of Mathematics, Findlay, OH 45840, and **Padmanabhan Seshaiyer**. *A two domain discontinuous solution to chemical transport in a small artery and arterial wall.*

In this presentation, a computational finite difference model of the Navier-Stokes equation in cylindrical coordinates is used to simulate blood flow in a small artery and is coupled to the advection diffusion equation in cylindrical coordinates to model chemical transport through the artery. Chemical transport through the arterial wall is modeled using diffusion, and coupled with the advection diffusion equation. This leads to a discontinuous two-domain solution of the chemical transport model in the artery and arterial wall. Additive Schwarz methodology is applied the two domain problem. An explicit finite difference scheme is used for the Navier-Stokes equation, and an implicit finite difference scheme is used on the advection diffusion equation. Error estimates for the chemical transport will be discussed, and numerical results will be presented. (Received September 22, 2010)

1067-65-2357 **Kening Wang*** (kening.wang@unf.edu), 1 UNF Drive, Department of Mathematics and Statistics, University of North Florida, Jacksonville, FL 32224, and **Shuang Li** (ben.shuangli@gmail.com), Derivative Valuation Center, Ernst & Young LLP, New York City, NY 10036. *L_q error estimates and superconvergence analysis for finite element methods for compressible miscible displacement.*

We investigate the finite element methods for a nonlinear parabolic system describing compressible miscible displacement in porous media. By introducing nonstandard elliptic projections and the new technique of approximating initial conditions, optimal order estimates in $L_q(\Omega)$ for $2 \leq q \leq \infty$ are obtained, where Ω is a bounded domain in $\mathcal{R}^2$. Moreover, superconvergence results for the error between the approximate solution and the elliptic projection of the exact solution in $W^{1,q}(\Omega)$ for $2 \leq q \leq \infty$ are also demonstrated. (Received September 22, 2010)

1067-65-2366 **Abdramane Serme*** (aserme@bmcc.cuny.edu), BMCC/CUNY-The City University of New York, Department of mathematics, N770, New York, NY 10007, and **Jean W. Richard** (jrichard@bmcc.cuny.edu), BMCC/CUNY-The City University of New York, Department of mathematics, N524, New York, NY 10007. *On the convergence of iterative refinement/improvement of the solution to an ill conditioned linear system.*

This talk is about improving the solution $x = A^{-1}b$ to an ill conditioned linear system $Ax = b$. We extend the classical the iterative refinement/improvement algorithm to the matrix equation $CW = U$ and compute $W = C^{-1}U$ in $I_r - V^H C^{-1}U$ using the following algorithm.

$$\begin{aligned} W_i &\leftarrow fl(C^{-1}U_i) = C^{-1}U_i - E_i \\ U_{i+1} &\leftarrow U_i - CW_i \end{aligned}$$

for $i = 0, 1, \ldots, k$, $U = U_0$ and $C(W_0 + \cdots + W_k) = U - CE_k$.we proved that if $\frac{||C^{-1}F_k||}{1-||C^{-1}F_k||} < 1$, where $F_k = C_k - C$, $X_k = W_0 + ... + W_k$ and $X = W$, then $||X_k - X|| \leq \mathcal{O}(\bar{u})$. By applying forward error analysis, we proved that $\frac{||X_k - X||}{||X||} \leq \mathcal{O}(u)$, and by applying backward error analysis we proved that $\lim_{k\longrightarrow\infty} \frac{||U_k - CW_k||}{||C||||W_k||}$ $= \frac{4c_1(k)}{1-c_1'(k)cond_2Cu}\bar{u}$, where $c_1(k)$ and $c_1'(k)$ are linear functions in k. In this talk we show how we improve the bound $\frac{4c_1(k)}{1-c_1'(k)cond_2Cu}\bar{u}$ and use it to prove the convergence of the error matrix $-E_k$ to zero as $k \longrightarrow \infty$ in the equation $C(W_0 + \cdots + W_k) = U - CE_k$. (Received September 22, 2010)

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1067-68-191 **Eddie B Tu** (eddietu@students.rmc.edu), 10513 Creston Road, Glen Allen, VA 23060, and **Bjorn S Wastvedt*** (bjorn.wastvedt@gmail.com), 435 West Neshannock Avenue, New Wilmington, PA 16142. *Applications of and Alternatives to Algorithm X for the Exact Cover Problem.*

Currently, the best algorithm for solving the NP-Complete Exact Cover problem is Donald Knuth's Algorithm X. Motivated by its efficiency, our work investigates conversion of other NP-Complete problems to Exact Cover form. We present an improvement on Sage's reformulation of Vertex Coloring problems to Exact Cover problems by using partial complete graph decompositions. This improvement generalizes the observation that the popular logic puzzle Sudoku is both an Exact Cover problem and a Vertex Coloring problem. After proving that chromatic polynomials cannot be used to find colorings of most arbitrarily partially-colored graphs, we turn to our method of conversion to find solutions. To solve the converted Vertex Coloring problem as well as the general Exact Cover problem, we present a detailed explanation of Algorithm X followed by an investigation into a new algorithm we developed to reduce any Exact Cover problem to a smaller exponential problem. Future research will address the comparative efficiency of these two algorithms in various conditions. (Received July 29, 2010)

1067-68-278 **Albert Fannjiang*** (fannjiang@math.ucdavis.edu), One Shields Avenue, Davis, CA 95616-8633. *Compressive imaging by the MUSIC algorithm.*

The MUSIC algorithm is analyzed from the compressed sensing perspective. Restricted isometry property is introduced to establish stability to perturbations. Superresolution effect of MUSIC is demonstrated. (Received August 15, 2010)

1067-68-533 **Jon Lee*** (jonlee@us.ibm.com), 1101 Kitchawan Road, Yorktown Heights, NY 10598. *A PTAS for matroid matching.*

Matroid parity was introduced in the '70s as a natural generalization of polynomially-solvable matching in general graphs and matroid intersection. Shortly thereafter, it was shown to have exponential complexity in the oracle model and to be efficiently solvable for linear matroids (in the cardinality case). We give a PTAS for the case of the oracle model based on a natural local search, and we show that the natural LP has poor properties. This is joint work with Maxim Sviridenko and Jan Vondrak. (Received September 08, 2010)

1067-68-584 **Akram Aldroubi*** (akram.aldroubi@vanderbilt.edu), 1520 Stevenson Center, Dept of Mathematics, Vanderbilt University, Nashville, TN 37240. *Non-linear signal representations, subspace clustering and some applications.*

There are new paradigms for signal representations that considers signals as elements of a union of subspaces in an ambient Hilbert space. This type of models is inherent is the theory of compressed sensing and signals with finite rates of innovation. Prototypical examples in which signals can be well modeled by a union of subspaces are the signals that are acquired from moving objects in video sequences and those acquired from facial views of a set human subjects in various positions and under various illuminations. Learning the models from the data allows us to track objects in video sequences and recognize faces from images. In this talk, we will explain how to learn the model from the data, and give some mathematical results showing the existence of optimal signal models. We then show how the models can be used to track moving objects in video sequences. (Received September 10, 2010)

1067-68-609 **Qin Wu*** (qinwu@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506, and **Eddie Fuller** and **Cun-Quan Zhang**. *Weighted Graph Model for Document Classification.*

In this paper, we propose a novel weighted graph model for document classification. The traditional methods use bag-of-word approach and they disregard any dependencies that may exist between words in the text. We

introduce a new approach that utilizes not only the keyword frequency but also their location and ordering. We derived a weighted directed graph model using the distances between the keywords as the weights of arcs. We then developed a keyword-frequency-distance based algorithm. This method is applied to the detection of plagiarism papers in IEEE journals and the result is much better than traditional methods. (Received September 22, 2010)

1067-68-808 **Mathieu Hoyrup*** (hoyrup@loria.fr), LORIA - 615, rue du jardin botanique, BP 239, 75011 Vandoeuvre-les-Nancy, France. *Algorithmic randomness and ergodic theorems.*

While many classical probability results are constructive in the sense of the algorithmic theory of randomness, several theorems from ergodic theory resist effectivization. I will present a survey of recent results in this direction. (Received September 15, 2010)

1067-68-1135 **Yasushige Watase*** (ywatase@ss.iij4u.or.jp), 4-17-1 Wakato, Nagano, Nagano 380-8553, Japan, **Noboru Endo** (endon@gifu-nct.ac.jp), Kamimakuwa 2236-2, Motosu, Gifu , Japan, and **Yasunari Shidama** (shidama@shinshu-u.ac.jp), 4-17-1 Wakato, Nagano, Nagano 380-8553, Japan. *Recent achievement of Codification on Real Analysis in Mizar.*

This talk is to introduce recent achievement of codification on real analysis and how it looks like. Area of the real analysis has been formalized in Mizar since early 1990s. Measure Theory formalized from1991 to 1996 due to sequential work of Jozef Bialas. Integral Theory has been formalized by Prof. Shidama's group at Shinshu University in Japan. Their work covered basic part of Integral Theory included Egoroff's theorem, Fatou's lemma and the Lebesgues's convergence thorem. Last two years Lebesgues space, the so-called Lp space, was formalized which included formal proof of Minkowski's inequality and Holder's inequality. (Received September 21, 2010)

1067-68-1246 **Yevgeniy Dodis**, **Mihai Patrascu** and **Mikkel Thorup*** (mthorup@research.att.com), 180 Park Avenue, Florham Park, NJ 07932. *Changing Base without Losing Space.*

We describe a simple, but powerful local encoding technique, implying two surprising results:

1. We show how to represent a vector of n values from a set Σ using $\lceil n \log_2 |\Sigma| \rceil$ bits, such that reading or writing any entry takes $O(1)$ time. This demonstrates, for instance, an "equivalence" between decimal and binary computers, and has been a central toy problem in the field of succinct data structures. Previous solutions required space of $n \log_2 |\Sigma| + n/\lg^{O(1)} n$ bits for constant access.

2. Given a stream of n bits arriving online (for any n, not known in advance), we can output a *prefix-free* encoding that uses $n + \log_2 n + O(\lg\lg n)$ bits. The encoding and decoding algorithms only require $O(\lg n)$ bits of memory, and run in constant time per word. This result is interesting in cryptographic applications, as prefix-free codes are the simplest counter-measure to extensions attacks on hash functions, message authentication codes and pseudorandom functions. Our result refutes a conjecture of [Maurer, Sjödin 2005] on the hardness of online prefix-free encodings. (Received September 20, 2010)

1067-68-1390 **Menaka B Navaratna*** (mnavarat@fgcu.edu), Dept. of Physical Sciences and Mathematics, 10501 FGCU Boulevard South, Fort Myers, FL 33965, and **Channa N Navaratna** (channa@iup.edu), Department of Mathematics, 210 South 10th Street, Indiana, PA 15705. *Tracing contaminants using non-linear filter approximation.*

The problem of accurately locating the origin of contaminant particles from noisy measurements obtained from a finite number of sensors is treated here. The physical system considered here consists of contaminant particles originating from an unknown location in a confined space which are being carried away by the airflow inside a room. The path of the particles is influenced by both air flow inside the room as well as the inherent random movement of the particles. Concentration of the particles at each sensor is measured at discrete time instances. These measurements are inaccurate due to additive random noise and will be processed under a particle filter algorithm to estimate the origin of contaminant particles. Extensive simulation experiments are carried out to show the effectiveness of particle filters in calculating the origin of contaminant. (Received September 20, 2010)

1067-68-1444 **Artur Kornilowicz*** (arturk@math.uwb.edu.pl), Institute of Informatics, University of Bialystok, ul. Sosnowa 64, 15-887 Bialystok, Podlaskie, Poland, and **Adam Naumowicz** (adamn@math.uwb.edu.pl), Institute of Informatics, University of Bialystok, ul. Sosnowa 64, 15-887 Bialystok, Podlaskie, Poland. *The language of mathematics in Mizar.*

Mizar is a state-of-the-art proof checker conceived to support mathematicians in their daily reasoning work. The underlying Mizar language has been designed to reconstruct mathematical vernacular in a computer-oriented environment. In this talk we will show how the natural language of mathematics can be encoded within the Mizar framework. We will present ways of defining notions like predicates, modes, adjectives (with and without so called "visible arguments"), functors, and structures. Various methods of formulating facts, e.g. theorems, schemes, registrations, and proof techniques provided by the system, e.g. diffuse reasoning, "per cases" reasoning, and definitional expansions will also be shown. Finally, we will discuss the most recent implementation of ellipsis. (Received September 21, 2010)

1067-68-1706 **Luca Trevisan*** (trevisan@stanford.edu), Computer Science Department, 474 Gates Building, 353 Serra Mall, Stanford, CA 94305-9025. *Khot's Unique Games Conjecture: its consequences and the evidence for and against.*

The theory of NP-completeness, developed in the early 1970s by Cook, Karp, Levin, and others, provides a conjectural approach to studying the computational complexity of several combinatorial problems. Under the widely believed conjecture that $P \neq NP$, proving that a problem is NP-complete implies that the problem does not admit a polynomial time algorithm.

The theory of Probabilistically Checkable Proofs (PCPs), developed in the 1990s, extended this approach to problems involving the search for *approximate solutions* to combinatorial optimization problems, establishing that for many problems the best possible polynomial time computable approximation guarantees are given by known algorithms (assuming $P \neq NP$).

Khot's Unique Games Conjecture (UGC), formulated in 2002, is a conjectural statement about the existence of certain PCP systems. If $P \neq NP$ and UGC holds, then a series of highly non-trivial results (involving techniques from geometry, harmonic analysis and probability) from the past eight years characterized the approximability of several additional problems.

We will discuss the evidence for and against the conjecture, and give a sample of the rich set of mathematical discoveries that have been motivated by it. (Received September 21, 2010)

1067-68-1936 **Damien Pitman*** (damien.pitman@cortland.edu), SUNY Cortland, Mathematics Department, PO Box 2000, Cortland, NY 13045. *Random 2-SAT Solution Components and a Fitness Landscape.*

We answer the following question: How many components are there in the subgraph of the discrete cube induced by the satisfying assignments to a random 2-SAT formula? We show that, for the probability range where formulas are likely to be satisfied, the random number of components converges weakly (in the number of variables) to a distribution determined by a Poisson random variable. The number of satisfying assignments or solutions is known to grow exponentially in the number of variables. Thus, our result implies that exponentially many solutions are organized into a stochastically bounded number of components. We also describe an application to biological evolution; in particular, to a type of fitness landscape where satisfying assignments represent viable genotypes and connectivity of genotypes is limited by single site mutations. The biological result is that, with probability approaching 1, each viable genotype is connected by single site mutations to an exponential number of other viable genotypes while the number of viable clusters is finite. (Received September 22, 2010)

70 ► Mechanics of particles and systems

1067-70-1042 **David T. Uminsky*** (duminsky@math.ucla.edu), UCLA Mathematics Department, Los Angeles, CA 90095-1555, and **Theodore Kolokolnikov**, **Hui Sun** and **Andrea Bertozzi**. *A theory of complex patterns arising from 2D particle interactions.*

Pairwise particle interactions arise in diverse physical systems ranging from insect swarms to self assembly of nanoparticles. In this talk we will present a theory for the morphology of patterns in two dimensions - which can range from ring and annular states to more complex spot patterns with N-fold symmetry. Many of these patterns have been observed in nature although a general theory has been lacking, in particular how small changes to the interaction potential can lead to large changes in self-organized state. Emergence of these patterns is explained by a stability analysis of a ring solution. This analysis leads to analytic formulae involving the interaction potential that provide detailed information about the structure of complex equilibria. (Received September 17, 2010)

1067-70-2050 **Hsin-Yuan Huang*** (huan0368@umn.edu), 420 Vincent Hall, 206 Church St. SE, Minneapolis, 55455. *On the Minimizing Total Collision Orbits in the Planar Newtonian N-body Problem.*

In this paper, we study the minimizing total collision orbits in the Newtonian planar n-body problem. We introduce the rotation angle with respect to the limiting configuration which naturally interprets how the total collision orbits approache the limiting configuration. The Painlevé-Winter problem is solved from the viewpoint of the variational method. It shows the infinite spin can not happen in these minimizing total collision orbits.

In the case of the planar three body problem with arbitrary masses, we show that for any given non-collinear initial configuration, the minimizing total collision path is collision free before it collides simultaneously and the particles approach to the Lagrange configuration closest to the initial configuration. (Received September 22, 2010)

74 ► Mechanics of deformable solids

1067-74-847 **Yury Grabovsky*** (yury@temple.edu), Wachman Hall 038-16, Rm. 638, 1805 N. Broad St., Philadelphia, PA 19122-6094, and **Lev Truskinovsky** (trusk@lms.polytechnique.fr), Laboratoire de Mécanique des Solides, Route de Saclay, 91128 Palaiseau CEDEX, France. *Why does nature go multiscale?*

We examine some of the necessary conditions for strong local minima for extremals with smooth surfaces of gradient jump discontinuity. The resulting overdetermined problem is responsible for the formation of fine scale microstructure via roughening instability. (Received September 15, 2010)

1067-74-1037 **Russell J Mahoney*** (rmahone1@gmu.edu), 9581 Bronte Dr., Burke, VA 22015, and **Maria G Emelianenko** (memelian@gmu.edu), Department of Mathematical Sciences, MS 3F2, 4400 University Dr, Fairfax, VA 22030. *Mathematical modeling of interface-dominated materials properties.*

Many materials used today are polycrystalline aggregates composed of large numbers of minuscule grains. These grains are separated by grain boundaries which determine the properties of the material, such as elasticity or conductivity. A combination of macro- and mesoscopic tools such as the finite element microstructure analysis package OOF2 and in-house grain growth evolution models is used to perform a comprehensive study of the dynamical effects grain coarsening has on these materials properties. By analyzing how these materials respond to stress, electricity, or heat, we learn more about the impact of grain boundary distributions. (Received September 17, 2010)

1067-74-1549 **Robert J Ronkese*** (rjronkese@gmail.com), Dept of Mathematical Sciences, United States Military Academy, West Point, NY 10996. *Asymptotic Models of the Nonlinear Adaptive Orthotropic Elastic Rod and Plate.*

Cancellous bone can be viewed as a lattice of asymptotically thin rods and plates. It is assumed that cancellous bone has at least orthotropic symmetries and the planes of orthotropic symmetry coincide with the fabric tensor. van Rietbergen et al. found that errors in the stress-strain calculation when using the orthotropic stiffness matrix instead of the full matrix amounts to a few percent or less. Cowan and Yang used a spectral decomposition method to and the average eigenbasis of stiffness matrices. They found that a set of human cancellous bone specimens had orthotropic symmetry at a 95% confidence level.

Considering the above, the orthotropic elastic rod and plate will be used in a model of bone remodeling first proposed by Cowin in the late 1970s. In each geometry, scalings will transform the stress and strain tensors in the original domains of the rod and of the plate into their scaled counterparts in enlarged domains. Simplifications will be made in he asymptotic expansions of the tensors and the displacement vector. The results will be used in ODEs governing the rate of bone growth and reabsorption whose formulations depend upon the geometry of the domain used. Results of numerical simulations will be presented. (Received September 21, 2010)

1067-74-1708 **Nicholas O. Kirby*** (nkirby@ms.uky.edu), 715 Patterson Office Tower, Lexington, KY 40506. *Stability of step dynamics in nanowire growth.*

A quasistatic version of the Burton-Cabrera-Frank model governing the growth of a nanowire is given by

$$\left\{\begin{array}{rcll} \frac{1}{r}\partial_r\left(r\partial_r\rho\right)+4 & = & 0 & \text{for } (0,r_1)\cup(r_1,r_2)\cup(r_2,1) \\ -\partial_r\rho|^+_{r=r_n} & = & K_+(\rho|^+_{r=r_n}+\frac{\gamma}{r_n}) & \text{for } n=1,2 \\ \partial_r\rho|^-_{r=r_n} & = & K_-(\rho|^-_{r=r_n}+\frac{\gamma}{r_n}) & \text{for } n=1,2 \\ \rho(0) & < & \infty & \\ \partial_r\rho|^+_{r=1} & = & 0 & \end{array}\right.$$

and

$$\dot{r}_n=\partial_r\rho|^+_{r=r_n}-\partial_r\rho|^-_{r=r_n},$$

where $K_\pm$ and γ are constants determined by the material and $0\le r_1\le r_2\le 1$. We are interested in whether certain step motions lead to step collisions (i.e., $r_1=r_2$), and will see that for any choice of material parameters, there is a non-trivial set U of initial step configurations which lead to step collisions. Finally, I will describe

rigorously how the size of the set U depends on the attachment parameters $K_\pm$ and the line tension γ. (Received September 21, 2010)

1067-74-1909 **Michael Stuebner*** (mstuebn@ncsu.edu), NCSU, Department of Mathematics, Box 8205, Raleigh, NC 27695, and **Robert P Lipton** (lipton@math.lsu.edu), LSU, Department of Mathematics, Lockett Hall, Baton Rouge, LA 70803. *Modeling damage evolution in high strength titanium alloys.*

In this talk we present a new multi-scale model for linking higher order micro-structure descriptions to failure initiation and crack propagation in high strength titanium alloys. The model gives an accurate local field description for predicting damage nucleation at the length scale of the polycrystalline texture. Current methods focus on average properties inside textured polycrystals and the overall effective response of structures due to macroscopic loading and are unable to capture local effects leading to damage nucleation and damage propagation. The new method allows the recovery of the explicit geometry of the damage micro structure inside the domains of microtexture and can capture the conditions for fatigue failure through propagation of a macro crack. Computational examples for damage evolutions for different load cases demonstrate the potential of our model. (Received September 22, 2010)

1067-74-2286 **James Christopher Halsall*** (jchalsall@yahoo.com), 747 Peekskill Street, Elmont, NY 11003-4905. *Analysis of Spherical Inflation Models for Intracranial Saccular Aneurysm Elastodynamics.* Preliminary report.

The motivation behind this research was to gain further insight as to the elastodynamics of the aneurismal wall and its long-term effects with regards to stability. Using calculus methods,reduction of order techniques,Runge-Kutta,and various ODE solvers,we obtained graphical data for the stretch ratio and the stretch rate of the aneurismal wall. The modeling of the cerebral aneurysm was specifically taken after spherical sac-like lesions. Both models only considered spherically symmetric geometries,which led to simplification of the pressure model of the cerebral spinal fluid when using the Navier-Stokes equation of motion in spherical coordinates. The model for the blood pressure was taken as being periodic,and a discrete Fourier Series and mean pressure element were used to model its behavior. Only a geometrically linear relationship between the strain and displacement of the aneurismal wall was considered. Following the same assumptions,we modified our stress function to take on alternative representations based upon specific strain functions. This work has been completed as a part of the 2010 REU Program at George Mason University funded by the NSF REU and DOD ASSURE Programs. (Received September 22, 2010)

76 ► Fluid mechanics

1067-76-216 **Sarah D Olson*** (solson2@tulane.edu), **Susan Suarez** and **Lisa Fauci**. *An Integrative Model of Hyperactivated Sperm Motility.*

Calcium (Ca2+) dynamics in mammalian sperm are directly linked to motility. These dynamics depend on diffusion, nonlinear fluxes, Ca2+ channels specific to the sperm flagellum, and other signaling molecules. The goal of this work is to couple Ca2+ dynamics to a mechanical model of a motile sperm within a viscous, incompressible fluid. An immersed boundary formulation of regularized Stokeslets is used to investigate the hydrodynamics and emergent waveforms and swimming speeds. We will present recent progress on elements of this integrative model. (Received August 05, 2010)

1067-76-243 **Leon Kaganovskiy*** (leonkag@gmail.com), 3525 Cheshire Square, apt B, Sarasota, FL 34237, and **Robert Krasny** (krasny@umich.edu), 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Numerical Simulation of Oblique and Head-on Collision.*

We employ a vortex sheet model and Lagrangian particle/panel method to represent vortex sheet surface motion in 3D incompressible flow to investigate the oblique and head-on collision of vortex rings. 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. The method allowed us to consider late stages of a vortex rings collision, producing individual ringlets similar to experiments. Vortex sheet approach allows us to see the details of ring's roll-up and vorticity iso-surfaces, as well as show ringlet formation behavior. (Received August 11, 2010)

1067-76-250 **Priya Shilpa Boindala*** (pboindala@gmail.com), 1000 University Center Ln, School of Science and Technology, Georgia Gwinnett College, Lawrenceville, GA 30043. *New Minimal Representation of Self Propelled Swimmers in Stokes Flow Using Regularized Fundamental Solutions.*

We develop a new representation of self propelled swimmers in low Reynolds number viscous incompressible flow that efficiently and effectively captures collective dynamics in free space and in the presence of a wall/boundary. The representation developed uses regularized fundamental solutions of the Stokes equation and is derived so as to retain the fluid flow features produced by an organism but using only one or two singularity elements. We call this "minimal swimmer" representation. In this talk I will describe the minimal swimmer representation derived and present the computational experiments used to validate it. The motility of suspensions of these organisms and their interactions give rise to recurring regions of re-circulation and whirls. These regions exist even when the inertial forces are negligible and play a key role in transport of nutrients or other solutes suspended in the system. This study has applications in Biofilms and transport in micro-fluid devices and taxis problems (Received August 12, 2010)

1067-76-289 **Lisa Melanson*** (l-melanson@northwestern.edu), Technology Institute, ESAM Department, 2145 Sheridan Road, Evanston, IL 60208. *Modeling of Intracranial Aneurysms using Immersed Boundary Methods.* Preliminary report.

Wall shear stresses, which are dependent on vessel geometry, can lead to changes in the material properties of arterial walls allowing aneurysms to grow and potentially rupture. In this study, we examine both elastic and rigid arterial wall models to explore how this remodeling is influenced by geometry and fluid stress. Using immersed boundary methods,we investigate the correlation between shear stress and aneurysm aspect ratio, outlet/inlet size, and tilt angle of the aneurysm. (Received September 21, 2010)

1067-76-514 **Dambaru Bhatta*** (bhattad@utpa.edu), Department of Mathematics, The University of Texas- Pan American, 1201 West University Drive, Edinburg, TX 78539, and **Daniel N. Riahi**. *Permeability effect on magneto-convection in a mushy layer.*

Here we consider a horizontal mushy layer which arises during solidification of binary alloys and study permeability effect on marginal stability due to magneto-convection in a mushy layer. The mushy layer, which has a permeable mush-liquid interface, is treated as a porous medium with variable permeability. The flow in the mushy layer can be described by a system of seven partial differential equations. We present our numerical results for effect of permeability on the flow. (Received September 07, 2010)

1067-76-822 **Mark A. Hoefer*** (mahoefer@ncsu.edu), Dept of Mathematics, North Carolina State University, Box 8205, Raleigh, NC 27695. *Oblique Shock Waves in Dispersive Eulerian Fluids.*

Two-dimensional, non-stationary oblique shock waves in a class of dispersive Eulerian fluids will be constructed using Whitham averaging. This construction takes advantage of irrotationality and recently developed methods for Whitham averaging of one-dimensional, non-integrable equations. General properties of weak non-stationary oblique shocks and their connection to stationary oblique shocks will be given. Example applications to Nonlinear Schrödinger (NLS) flows, water waves, ion-acoustic plasma, and optical media with saturable nonlinearity will be presented. Connections to supersonic dispersive, NLS flow over corners will also be discussed. (Received September 15, 2010)

1067-76-960 **Andong He*** (he@math.psu.edu), 10 Vairo Blvd., Apt 31C, State College, PA 16803, and **Andrew Belmonte**. *Inertial effects on viscous fingering in the complex plane.*

We present the generalized Darcy's equation, which includes inertial effects for flows in Hele-Shaw cells, and discuss when it reduces to the classical Darcy's law. A generalized Polubarinova-Galin equation in the complex plane is derived for a circular geometry. The linear stability of the base-flow state is examined by perturbing the corresponding conformal map - we show that inertia always has a tendency to stabilize the interface. (Received September 16, 2010)

1067-76-1077 **Hui Sun*** (huiprobable@math.ucla.edu), UCLA Mathematics Department, Los Angeles, CA 90095, **Uminsky David**, UCLA, Mathematics Department, Los Angeles, CA 90095, and **Bertozzi Andrea**, UCLA Mathematics Department, Los Angeles, CA 90095. *Generalized Birkhoff-Rott equation for 2D active scalar problems.*

In this talk we derive new evolution equations for the active scalar problem in 2D for the case when all scalars lie on a 1D curve, analogous to the Birkhoff-Rott equation for 2D vorticity. The new equations are Lagrangian and valid for nonlocal kernels K that may include both a gradient and an incompressible term. We develop a numerical method for implementing the model which achieves second order convergence in space and fourth order in time. We simulate several classic vortex sheet examples (in the case of a purely incompressible kernel) and the collapse of delta ring solutions (in the case of a pure gradient kernel) and find excellent agreement with our new model. We then analyze two examples that include both incompressible and gradient parts, the first is a model for superfluids and the second a model for collective biological motion and discuss the results. (Received September 18, 2010)

1067-76-1091 **Ahmed kaffel*** (kaffel@vt.edu), 1404 J university city blvd, Blacksburg, VA 24060, and **Michael Renardy**. *Surface modes in inviscid free surface shear flows.*

We investigate the linear stability of inviscid plane Poiseuille flow between two parallel free surfaces. We show that there are short wave instabilities with eigenfunctions localized near the free surface and derive the asymptotics of these modes. (Received September 18, 2010)

1067-76-1364 **M. Hameed*** (mhameed@uscupstate.edu), University of South Carolina Upstate, Division of MCS, 800 University Way, Spartanbburg, SC 29303, and **J. Morris**. *Mathematical model of a liquid jet breakup containing solid particles.*

The phenomenon of liquid jet breakup is studied for the case of a very viscous jet containing one or more solid particles. A mathematical model is derived which represents the complex dynamics as a combination of two relatively simpler problems. 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, also termed a stresslet. The total flow field is the combination of the "outer" long wavelength approximated flow, combined with the "inner" flow induced by the force dipole representation of a particle. Imposing the standard stress balance and kinematic condition at the jet surface to the combined flow leads to a well-posed problem for the evolution of the jet shape. The model equations are solved numerically by an implicit finite-difference scheme. The theoretical calculations based on this hybrid long wavelength and singularity approach yield qualitatively accurate and encouraging agreement with experimental observations. Results of calculations for one particle centered or off-center and for two particles are presented. Results showing the influence of varying particle size are also presented. (Received September 20, 2010)

1067-76-1374 **Kevin Talbott*** (ktalbott@gmu.edu), 4307 Salina Ct., Fairfax, VA 22030. *Modeling the Evaporation of a Tear Film over a Contact Lens.*

A contact lens is porous and thus fluid can flow between the Post-lens Tear Film (PoLTF), which is the fluid between the corneal surface and the contact lens, and the Pre-Lens Tear Film (PrLTF), which is the fluid on top of the contact lens exposed to the air. Our tear film model allows for fluid transfer through the lens and includes the effects of evaporation of the PrLTF. Governing equations include Navier-Stokes equations, heat equation and Darcy's equation for the fluid flow and heat transfer in the fluid film and porous layer. In a one-dimensional tear film model, parameters are changed to find possible steady state solutions and the time it takes to reach them. Also of interest is the possible depletion of the PoLTF via evaporation of the PrLTF. The one-dimensional model can be reduced to an ODE that can be solved numerically or analytically. We also explore a two-dimensional tear film model described by a PDE that is first order in time and fourth order in space. (Received September 20, 2010)

1067-76-1419 **Matthew J Glomski*** (matthew.glomski@marist.edu), School of Computer Science and Mathematics, Marist College, 3399 North Road, Poughkeepsie, NY 12601, and **Matthew Adam Johnson** (matthew.johnson1@marist.edu), School of Computer Science and Mathematics, Marist College, 3399 North Road, Poughkeepsie, NY 12601. *A precise calculation of the critical Rayleigh and Wave Numbers for the Inhomogeneous Planar Bénard Problem.*

Rayleigh-Bénard convection is a much researched thermodynamical phenomenon, yet significant questions remain. In this talk, we will present one new result: a verified calculation of the critical Rayleigh number R_* and critical wave number k_* for the inhomogeneous planar Bénard problem. Our methods draw on both error-bounded interval computations, as well as more traditional analytic techniques of classical fluid dynamics. (Received September 21, 2010)

1067-76-1655 **David C Szurley*** (dszurley@fmarion.edu), 405 N Ebenezer Rd., Florence, SC 29501. *Numerical Simulation of Fiber Spinning Including Flow-Induced Crystallization.*

Today's society has in great abundance products that are made from polymers: clothing made from synthetic fibers, plastic bags, food wrap, and disposable diapers are among the most common examples. It has become imperative for today's manufacturers to understand the processes used to make these products as fully as possible. Numerical simulation is a powerful tool which can be used for this purpose.

In this talk, we will consider equations modeling fiber spinning that include the phenomenon of flow-induced crystallization. The process of fiber spinning will be discussed and the equations will be introduced. Difficulties in the numerical simulation of the model will be addressed and solutions will be presented. (Received September 21, 2010)

1067-76-1846 **Sadia M.. Makky*** (sadia_makky@Owens.edu), 18547 Clairmont circle E, Northville, MI 48168, and **ALI M. Ghalib** and **Thaer S. Sliby**. *Thermal and mass flow in uniform stream with a sink and a heat source via variational technique for free boundary problems.*

A stream with parallel sides, moving with uniform speed and with constant temperature is considered. Stream water at a certain location is taken continuously (sink) as coolant; the heated water is dumped back to the straem at a further location along the stream flow direction (source). The problem is to find the minimum distance between the source and sink that insures the stability of water temperature; in the sense that sink water temperature does not increase.

The problem is solved as a free boundary problem by two methods, finite elements, and variational techniques. Both methods give almost identical results, thus indicating the validity of both. Only variational approach is discussed in this article. (Received September 22, 2010)

1067-76-1928 **Rebecca A Segal*** (rasegal@vcu.edu), Department of Mathematics, Virginia Commonwealth University, PO Box 842914, Richmond, VA 23284-2014. *Deposition Patterns of Nanoparticles in Human Nasal Passages.* Preliminary report.

Differences in nasal anatomy among human subjects leads to significant differences in respiratory airflow patterns and the subsequent dosimetry of inhaled gases and particles in the respiratory tract. This study used computational fluid dynamics (CFD) to study inter-individual differences in particle deposition patterns. Steady-state inspiratory laminar airflow at 15 L/min was calculated using commercial CFD software. Deposition of nanoparticles were calculated using a user defined function and deposition patterns were compared between subjects. (Received September 22, 2010)

1067-76-2026 **Nathaniel Mays***, 301 Thackeray Hall, University of Pittsburgh, Pittsburgh, PA 15260, and **Ross Ingram**, **Iuliana Stanculescu** and **Carolina Manica**. *Approximations to the Navier-Stokes equation using a Leray-Iterated-Tikhonov model with Time Relaxation.* Preliminary report.

The Navier-Stokes equations (NSE) constitute a well-accepted continuum model for incompressible, viscous, Newtonian fluids with a wide range of applications in climate modeling, energy sciences, and bio-engineering. Regularization methods are an enticing approach of approximating the NSE solutions due to their simple and efficient implementation. In this talk, we will look at a particular method, the Iterated-Tikhonov deconvolution model to the Leray approximation model of the NSE. We will show convergence of the method, and a numerical experiment supporting the theoretical results. (Received September 22, 2010)

1067-76-2045 **Antonio Mastroberardino*** (axm62@psu.edu), 4205 College Drive, Erie, PA 16563. *Annular stagnation flow on a moving cylinder.*

In various industrial applications, fluid is injected from a fixed outer cylindrical casing onto an inner moving cylindrical rod. This scenario is particularly important in pressure-lubricated bearings. Using a similarity transformation, the Navier-Stokes equations that govern this type of flow reduce to a 4th order nonlinear boundary value problem. In this presentation, I will provide analytical solutions to this ordinary differential equation using the homotopy analysis method and compare these results with numerical solutions. (Received September 22, 2010)

1067-76-2219 **Michael G Dabkowski*** (dabkowsk@math.wisc.edu), 619 S. Orchard Apt.1, Madison, WI 53715. *Eventual Regularity of the Solutions to the Supercritical Dissipative Quasi-Geostrophic Equation.*

Recently, Silvestre proved that certain weak solutions of the slightly supercritical surface quasi-geostrophic equation eventually become smooth. To prove this, he employed a De Giorgi type argument originated in the work of Caffarelli and Vasseur. Kiselev and Nazarov proved a variation of the result of Caffarelli and Vasseur by introducing a class of test functions. Motivated by the results of Silvestre, we will modify the class of test functions from the work of Kiselev and Nazarov and use this modified class to show that a solution to the supercritical SQG that is smooth up to a certain time must remain smooth forever. (Received September 22, 2010)

1067-76-2313 **Milton C. Lopes Filho*** (mlopes@ime.unicamp.br), IMECC-UNICAMP, Rua Sergio Buarque de Holanda, 651, Campinas, SP 13083-859, Brazil. *Newtonian limits of complex fluid models.*

We consider two complex fluid models, the second-grade fluid equations and its inviscid version, called the Euler-α system. We are interested in conditions on the regularity of the flow to obtain convergence in the limit $\alpha \to 0$, and its uniformity with respect to viscosity. We study the special case of bounded domains with Navier friction condition. (Received September 22, 2010)

78 ► Optics, electromagnetic theory

1067-78-1149 **Paul M Bellan*** (pbellan@caltech.edu), 128-95 Caltech, 1200 E. California Blvd, Pasadena, CA 91107. *Self-organization resulting from conservation of magnetic helicity, a distributed form of linkages; applications to lab and solar phenomena.*

A magnetic field (or any other solenoidal field) can have one part of the field link another. This generalization of knottedness extends to the field having linkages, twist, and writhe which are topologically mutually equivalent; helicity accounts for all of these forms. Magnetic helicity is more "robust" than magnetic energy in the sense that fine-scale rearrangements (e.g., conversion of linkage to twist or writhe) dissipates magnetic energy while conserving magnetic helicity. Unstable systems seek a minimum energy state whereby twists, writhe, and linkages exchange to minimize energy while conserving helicity. The resulting state, called a relaxed state, is a unique meta-equilibrium towards which instabilities drive any arbitrary initial state; i.e., the system self-organizes. Spheromaks and reversed field pinch fusion plasma configurations are practical examples of such self-organized systems. Solar corona loops are similar, the main difference being the boundary conditions. If excessive helicity is injected into a configuration for given boundary conditions, no relaxed state exists and the system burps off a bubble-like structure containing the excess helicity. Spheromak formation and solar loops/prominence eruption involve this mechanism. (Received September 19, 2010)

1067-78-1198 **Gang Bao*** (bao@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 18824-1027, and **Junshan Lin** (warrenprince@gmail.com). *Inverse scattering via near-field imaging.* Preliminary report.

The talk is concerned with our recent study of the inverse scattering problem from near-field or far-field boundary measurements. A novel approach will be discussed on solving the interface determination problem, which is ruled on a perfect conductor. When near-field information is available, the approach is shown to be able to break the diffraction limit. When the interface is of multiscale, a multiple frequency method may be developed. The speaker will also discuss various issues related to the topic. (Received September 21, 2010)

1067-78-1464 **Patrice D. Benson*** (patrice.benson@usma.edu), USMA West Point, Mathematical Sciences Department, 646 Swift Road, West Point, NY 10996, and **Anjan Biswas**, **Dawn A. Lott** and **Daniala Milovic**. *Super-Sech Solitons in Optical Fibers via the Variational Principle.*

This research is the study of optical solitons via the variational principle and the relevance to the field of fiber optic communications. In particular, this problem explores the propagation of nonlinear information along an optical fiber by obtaining the evolution equations. The variational principle has been shown to be a very beneficial method since it can lay down the parameter dynamics of all the soliton parameters even if the governing equation is not integrable.

In the variational method the Lagrangian of the governing equation is constructed first. From Lagrangian, the Euler-Lagrange's (EL) equations are used to construct the parameter dynamics of the soliton parameters. In presence of perturbation terms, the modified version of EL equations are used to lay down the adiabatic parameter dynamics of optical solitons.

The pulse shape employed in this study was the super-sech function. Solitons in polarization preserving fibers, birefringent fibers, as well as in dense wavelength-division multiplexing systems were taken into consideration. The adiabatic parameter dynamics of soliton parameters were obtained in the presence of perturbation terms. The numerical simulations were performed to complete the analysis. (Received September 21, 2010)

1067-78-1582 **Weiwei Zhang***, 133, North River Street, Wilkes-Barre, PA 18702. *Electromagnetic Scattering from Large Cavities.*

In this talk, I will present a modified mode matching method to calculate the Electromagnetic field scattered from large open cavity which is recessed in an infinite ground plan. The problem can be served as a model of duct structures, such as jet engine intakes of an aircraft or antenna windows embedded in complicated structures. The phenomena are governed by the Helmholtz equation (2D) and the Maxwell's equations (3D) with suitable boundary conditions. The calculations of Radar Cross Section (or echo area) of this structure are considered and the numerical experiments are studied. (Received September 21, 2010)

81 ► Quantum theory

1067-81-71 **Ezekiel Olusola Ayoola*** (eoayoola@googlemail.com), Department of Mathematics, University of Ibadan, Ibadan, Nigeria. *Arc-wise connectedness of solution sets of quantum stochastic differential inclusions.*

We show that the sets of solutions of quantum stochastic differential inclusions driven by stochastic processes associated with the basic field operators of quantum field theory are arc-wise connected. The results hold within the framework of the Hudson-Pathasarathy formulation of quantum stochastic calculus. This complements similar results in the classical cases of differential inclusions defined on finite dimensional Euclidean spaces. (Received July 10, 2010)

1067-81-157 **Curt D Cenci*** (curtcenci@gmail.com), 1031 N 7th St, Emmaus, PA 18049. *Classification of symmetric states under local unitary action.*

Quantum algorithms rely on an algebraic property of composite quantum systems called entanglement. Currently, there is no complete classification of quantum states by their entanglement types. By exploiting local unitary stabilizer subgroups and properties of Lie algebras, we obtain results classifying the set of quantum states which are invariant under particle interchange, called symmetric states. These states are of particular interest in experimental quantum information due to their relative computational simplicity. For symmetric states whose local unitary stabilizers have a positive number of continuous degrees of freedom, the classification is exhaustive. This talk will focus on these states, as well as give some interesting examples of symmetric states with discrete stabilizers. (Received July 28, 2010)

1067-81-707 **Stephen Bruce Sontz*** (sontz@cimat.mx), CIMAT, Jalisco s/n, Mineral de Valenciana, 36240 Guanajuato, Gto., Mexico. *Restriction principles in Segal-Bargmann analysis associated to a Coxeter group.*

We will present recent results about restriction principles (a special case of the polar decomposition of a closed operator from functional analysis) applied to the versions of the Segal-Bargmann transform associated to a Coxeter group in Euclidean space and its corresponding Dunkl operators. (Received September 13, 2010)

1067-81-1173 **Iana I Anguelova*** (anguelovai@cofc.edu), College of Charleston, Math Department, 66 George Street, Charleston, SC 29424. *Bicharacter construction for boson-fermion correspondences.* Preliminary report.

The charged free boson-fermion correspondence plays an important role in the representation theory of the a_∞ algebra, as well as for the KP hierarchy. It is an isomorphism between two super vertex algebras (and so with singularities in the OPEs only at $z = w$). The boson-fermion correspondence of type B plays a similar role in the representation theory of the b_∞ algebra and for the BKP hierarchy. The vertex operators describing it have singularities in the OPEs at both $z = w$ and $z = -w$, and thus need a more general notion than a super-vertex algebra. This is the simplest, and important, example of what we call a "T-generalized vertex algebra" (with singularities in the OPEs at $z = \epsilon w$, where ϵ is a root of unity). In this talk we present a bicharacter construction of the boson-fermion correspondence of type B as isomorphism of T-generalized vertex algebras. This bicharacter structure is then used for studying the properties of the T-generalized vertex algebras. Further, a similar bicharacter construction is used for producing other examples of boson-fermion correspondences. Partly joint with Maarten Bergvelt, UIUC. (Received September 23, 2010)

1067-81-1420 **Paolo Aluffi** (aluffi@math.fsu.edu), Department of Mathematics, Florida State University, Academic Way, Tallahassee, FL 32306, and **Matilde Marcolli*** (matilde@caltech.edu), Department of Mathematics, California Institute of Technology, 1200 E California Blvd, Pasadena, CA 91125. *From Feynman diagrams to Potts models: a motivic approach.* Preliminary report.

The occurrence of periods of mixed Tate motives as values of residues of Feynman graphs in perturbative quantum field theory became the object of extensive studies in recent years, centered around the motivic properties of the graph hypersurfaces, which arise naturally in the parametric formulation of Feynman integrals. We showed that a partial form of deletion-contraction relation holds for the classes of these graph hypersurfaces in the Grothendieck ring of varieties. We now argue that the same techniques can be applied to another class of hypersurfaces, associated to Potts models in statistical mechanics, and the resulting deletion-contraction formulae lead to a motivic approach to the problem of phase transitions. (Received September 21, 2010)

1067-81-1421 **Ivan Gonzalez*** (ivan.gonzalez@utfsm.cl), Departmento de Fisica, Universidad Santa Maria, Valparaiso, Chile. *The basic physics of Feynman diagrams.*

Feynman diagrams represent a pictorial technique to describe the interaction of fundamental particles. This talk will introduce the basic Physics associated to these diagrams. The Schwinger parametrization of the diagram expresses the particle interaction as a multi-dimensional integral. (Received September 21, 2010)

1067-81-1500 **Scott A. Yost*** (scott.yost@citadel.edu), Department of Physics, The Citadel, 171 Moultrie St., Charleston, SC 29409, and **Vladimir V. Bytev**, **Mikhail Yu. Kalmykov**, **Bernd A. Kniehl** and **B. F. L. Ward**. *The Hypergeometric Representation of Feynman Diagrams and Construction of the Epsilon Expansion.*

We present results on hypergeometric function representations of Feynman diagrams. Following a review of these representations and some examples, we discuss the reduction of Feynman diagrams to master integrals, and compare integration-by-parts methods to differential reduction of hypergeometric functions. We describe the problem of constructing higher-order terms in the epsilon expansion, and characterize the functions generated in such expansions. (Received September 21, 2010)

1067-81-2099 **Evgeny Mukhin*** (mukhin@math.iupui.edu), Department of Mathematics, 402 N. Blackford St., LD 270, IUPUI, Indianapolis, IN 46202. *Representations of quantum toroidal $gl(1)$.*

Representation theory of the quantum toroidal algebra of $gl(1)$ type is a surprising tool to study of the representations of more standard objects such as $gl(\infty)$ or W_N algebras. The reason is that for this algebra, the singular vectors in the tensor products are often given by just one monomial (no linear combinations appear). On the other hand, $gl(\infty)$ and W_N algebras are obtained by taking appropriate factorizations and limits.

We discuss a large class of the modules over the quantum toroidal $gl(1)$ together with their degenerations which allows us to obtain simple combinatorial descriptions of various $gl(\infty)$ and W_N modules.

It is a report on a joint project with B. Feigin, E. Feigin, M. Jimbo and T. Miwa. (Received September 22, 2010)

82 ► Statistical mechanics, structure of matter

1067-82-44 **Zhongyang Li*** (zli@math.brown.edu), 151 Thayer Street, Providence, RI 02912. *Critical Temperature of Ising Ferromagnets and Spectral Curve of Dimers.*

We prove the uniqueness of the translation invariant Gibbs measure for dimer models on a large class of periodic Fisher graphs, with arbitrary but finite period. As a result, we identify the critical temperature, defined by the supreme of the temperatures at which the spontaneous magnetization of a periodic, ferromagnetic Ising model is nonzero, and the condition that the spectral curve of the corresponding dimer model on the Fisher graph has a real node on the unit torus. A simple proof for the exponential decay of spin-spin correlations above the critical temperature for the symmetric, periodic Ising ferromagnet, as well as the exponential decay of the edge-edge correlations for all non-critical edge weights of the dimer model on periodic Fisher graphs, is obtained by our technique. (Received June 16, 2010)

1067-82-218 **Mei Yin*** (emma_yin@hotmail.com), 1 University Station C1200, Austin, TX 78712. *A Cluster Expansion Approach to Renormalization Group Transformations.*

The renormalization group (RG) approach is largely responsible for the considerable success achieved in developing a quantitative theory of phase transitions. This work treats the rigorous definition of the RG map for

Ising-type classical lattice systems. A cluster expansion is used to justify the existence of the linearization of the renormalized interaction in the infinite volume limit at high temperature. This expansion is derived from the formal expressions, but it is itself well-defined and convergent. (Received August 07, 2010)

1067-82-496 **Kay L Kirkpatrick*** (kay.kirkpatrick@gmail.com). *Bose-Einstein condensation, the NLS, and a phase transition.*

Near absolute zero, a gas of quantum particles can condense into an unusual state of matter, called Bose-Einstein condensation, that behaves like a giant quantum particle. Recently we've been able to make the rigorous probabilistic connection between the physics of the microscopic dynamics and the mathematics of the macroscopic model, the cubic nonlinear Schrodinger equation (NLS).

I'll mention joint work with Benjamin Schlein and Gigliola Staffilani on the two-dimensional cases for Bose-Einstein condensation–and the periodic case is especially interesting, because it uses techniques from analytic number theory and has applications to quantum computing. I'll also describe new work with Sourav Chatterjee about a phase transition for the invariant measures of the NLS, work which sheds light on typicality of blow up as well as a controversial conjecture of Lebowitz, Rose, and Speer. (Received September 07, 2010)

1067-82-1229 **Erik J. Jensen*** (jensene@email.unc.edu), Dept. of Mathematics, UNC-CH, CB 3250 Phillips Hall, Chapel Hill, NC 27599-3250, and **Alexander Varchenko** (anv@email.unc.edu), Dept. of Mathematics, UNC-CH, CB 3250 Phillips Hall, Chapel Hill, NC 27599-3250. *Norms of eigenfunctions to trigonometric KZB operators.*

Let $\mathfrak{g}$ be a simple Lie algebra and $V[0] = V_1 \otimes \cdots \otimes V_n[0]$ the zero weight subspace of a tensor product of $\mathfrak{g}$-modules. The trigonometric KZB operators are commuting differential operators acting on $V[0]$-valued functions on the Cartan subalgebra of $\mathfrak{g}$. Eigenfunctions to the operators are constructed by the Bethe ansatz. We introduce a scalar product such that the operators become symmetric, and the square of the norm of a Bethe eigenfunction equals the Hessian of the master function at the corresponding critical point. (Received September 20, 2010)

1067-82-1732 **Ross Robert Kistler*** (rrkistler@loyola.edu), 8771 Hickory Hill, Walkersville, MD 21793. *Distributional Sensitivity in Polycrystalline Grain Growth Simulations.*

Polycrystalline materials have many uses in the industrial world. In my presentation we explore the impact of grain growth on the viability of industrial materials and demonstrate the value of an accurate simulation. We have modified a preexisting one dimensional model of polycrystalline materials to produce a probability distribution of the misorientations of individual grains. We will examine the effects of varying the initial conditions of the simulation and demonstrate how the Radon-Nikodym Theorem can be used to quantify the differences between two probability distributions. This quantity is known as the distributional sensitivity. It will be used to illustrate how sensitive the grain boundaries of a polycrystalline material are to changes in initial conditions, and how the information gathered from these experiments can be used in the future.

This work has been completed as a part of the 2010 REU Program at George Mason University funded by the NSF-REU and DOD-ASSURE Programs. (Received September 21, 2010)

1067-82-1736 **C Soteros*** (soteros@math.usask.ca), Department of Mathematics and Statistics, University of Saskatchewan, 106 Wiggins Road, Saskatoon, SK S7N5E6, Canada. *Entanglement Statistics for lattice models of polymer systems.*

Using self-avoiding walk and polygon models on the simple cubic lattice, we have been investigating questions about the entanglement complexity of polymer systems. In this talk, I will review recent numerical results (obtained in collaboration with Dr. M. Szafron) on how the knot reduction factor depends on the local juxtaposition structure at a strand passage site in a random lattice polygon. In particular, we see a correlation between the knot reduction factor and the angle of the crossing at the strand passage site; this same angle has been shown experimentally by Neuman et al (2009) to be important in explaining topoisomerase action on DNA. I will also review theoretical results (obtained in collaboration with Dr. M. Atapour) on the entanglement complexity of systems of self-avoiding walks in lattice tubes with applications to measuring entanglement in dense polymer systems. (Received September 21, 2010)

1067-82-1833 **Paul H Jung*** (pjung@sogang.ac.kr), Department of Mathematics, Sogang University, Seoul, South Korea, and **Michael Aizenman** and **Sabine Jansen**. *Symmetry breaking in quasi-1D Coulomb systems.*

Quasi one-dimensional systems are systems of particles in domains which are infinite in one direction and uniformly bounded in all other directions, e.g. a cylinder of infinite length.

Our main result is that for such particle systems with Coulomb interactions and neutralizing background, the so-called "jellium", at any temperature and at any finite-strip width there is translation symmetry breaking.

The argument used here bypasses the question of whether the translation symmetry breaking is manifest already at the level of the one particle density function. It is akin to that of Aizenman and Martin (1980) for a similar statement concerning symmetry breaking at all temperatures in strictly one-dimensional Coulomb systems. The extension is enabled through bounds which establish tightness of finite-volume charge fluctuations. (Received September 22, 2010)

83 ► Relativity and gravitational theory

1067-83-1984 **Amir Babak Aazami*** (aazami@math.duke.edu), Department of Mathematics, Duke University, Durham, NC 27708. *Orbifolds, the A, D, E Family of Caustic Singularities, and Gravitational Lensing.*

We provide a geometric explanation for the existence of magnification relations for the A $(n \geq 2), D$ $(n \geq 4), E_6, E_7, E_8$ family of caustic singularities, which were established in recent work. In particular, it was shown that for families of general mappings between planes exhibiting any of these caustic singularities, and for any non-caustic target point, the total signed magnification of the corresponding pre-images vanishes. As an application to gravitational lensing, it was also shown that, independent of the choice of a lens model, the total signed magnification vanishes for a light source anywhere in the four-image region close to elliptic and hyperbolic umbilic caustics. This is a more global and higher-order analog of the well-known fold and cusp magnification relations. We now extend each of these mappings to weighted projective space, which is a compact orbifold, and show that magnification relations translate into a statement about the behavior of these extended mappings at infinity. This generalizes multi-dimensional residue techniques developed in previous work, and introduces weighted projective space as a new tool in the theory of caustic singularities and gravitational lensing. (Received September 22, 2010)

1067-83-2211 **Alberto M Teguia***, 728 Glen Hollow Dr, Durham, NC 27705, and **Arlie Petters**. *Geometry of the Random Time Delay Surface and the Expected Number of Lensed Images in Microlensing.* Preliminary report.

We consider a gravitational lensing scenario where the lens is a collection of random stars. We study the resulting random shear tensor, obtaining its asymptotic probability density function in the large number of stars limit. This gives information on the geometry of the random time delay surface through a relation between the shear tensor and the Gauss curvature of the surface. We then use these results to obtain the first moment of an important physical observable: The random number of minimum images produced by the lensing scenario under consideration. (Received September 22, 2010)

86 ► Geophysics

1067-86-150 **Danielle Nicole Gannon***, 11283 CR 24, Middlebury, IN 46540, and **Natalie Domelle** and **Lucy Flesch**. *Preliminary Report on the Modeling of Surface Velocities and Fault Rotations.* Preliminary report.

It has been proposed that coherent rotational structures can be modeled using an extension of traditional continuum mechanics known as polar field theory. Surface velocities were plotted using Generic Mapping Tools software with GPS data taken from previous research. Some of the data had variances that were half or more of their observed velocities and were removed in order to obtain a better model. This model was then used to spline interpolate between observed strain rates inferred from GPS data to determine a continuous deformation tensor for the western United States. The tensor was used to find the internal and external rotation along faults. External rotation was calculated with the equation: $\frac{d\theta}{dt} = \omega + \epsilon_{xy}\cos(2\theta) + \frac{1}{2}[\epsilon_{yy} - \epsilon_{xx}]\sin(2\theta)$, where $\frac{d\theta}{dt}$ is external rotation, ω is observed rotation, $\epsilon_{xx}, \epsilon_{yy}$ and ϵ_{xy} are strain rates, and θ is the strike of the fault. Internal rotation was found by subtracting the external rotation from the observed rotation. By obtaining the rotations, we can find areas in the western United States that are rotating uniformly and this will be used to identify coherent structures, to be utilized in the model. (Received July 27, 2010)

1067-86-346 **Nicholas R Gewecke*** (gewecke@math.utk.edu) and **Tim P Schulze**. *Evolution of a Mushy Zone on a Finite Domain.* Preliminary report.

Mushy zones are regions of intermixed liquid and solid which most often result from instability due to the build-up of solute during the solidification of multispecies materials. In a typical experiment, a uniformly mixed solution is placed onto a cold boundary, inducing the growth of a thin solid layer, capped by an initially expanding mushy zone. Growth slows as the solution is depleted of the material forming the dendrites. Common modeling assumptions include an infinite domain and negligible solute diffusion, but restricting the domain and incorporating solute diffusion changes the transient and long-term dynamics of the system. These modified dynamics may be of geological interest. Over long time scales, the mushy zone vanishes, leaving a solid layer in equilibrium with a liquid layer consisting of a uniform solution which differs from the original solution. The transient dynamics in the case of a very cold boundary lead to variations in the amount of solute which is frozen into the solid, which may have consequences for solids such as rock layers formed during the cooling of magma. (Received August 25, 2010)

1067-86-404 **W. Van Snyder*** (van.snyder@jpl.nasa.gov), Jet Propulsion Laboratory, 4800 Oak Grove Drive, Mail Stop 183-701, Pasadena, CA 91109-8099. *Data Analysis for the EOS Aura Microwave Limb Sounder.*

The Microwave Limb Sounder is one of four instruments on NASA's AURA satellite, which was launched on 15 July 2004 into a near-polar 705 km sun-synchronous orbit. It makes passive measurements of thermal radiation from the Earth's limb in ~ 1000 channels in five microwave bands, from 118 GHz to 2.5 THz, scanning from the ground to 90km altitude at the limb every 25 seconds. From > 500 million measurements, it produces ~ 5 million estimates of atmospheric composition, temperature, humidity, and cloud ice at 70 pressure levels on ~ 3500 orbit-track profiles per day. Geophysical parameters are estimated from microwave spectra by inverting the radiative transfer equation using a classical Gauss-Newton iteration. The Newton move is calculated by solving a least-squares problem in which the Jacobian matrix is augmented with apriori information, Tikhonov regularization, and Levenberg-Marquardt stabilization. Processing is carried out using a 48-node cluster, each node having two quad-core 3 GHz Intel Nehalem processors and 16 GB memory. Parallelization consists of assigning ~ 20 scans of the antenna to each core, which then spend a few minutes communicating with a master before and after computing in isolation for ~ 15 hours. (Received September 01, 2010)

1067-86-546 **Isabel Ostermann*** (osterman@itwm.fraunhofer.de), Fraunhofer ITWM, Fraunhofer-Platz 1, 67663 Kaiserslautern, Germany. *3D-Modeling of Heat Transport in Deep Hydrothermal Reservoirs.* Preliminary report.

From a mathematical point of view, there are three building blocks of deep geothermal power: seismic exploration, modeling transport processes, and modeling the stress field. In particular, local depletion poses a significant risk during the industrial utilization of geothermal reservoirs. In order to reduce this risk, reliable techniques to predict the heat transport and the production temperature are needed. To this end, a 3D-model to simulate the heat transport in hydrothermal systems is developed that is based on a transient advection-diffusion-equation. In addition to the solution theory, a numerical solution method and numerical tests are presented. (Received September 09, 2010)

1067-86-842 **Frederik J Simons*** (fjsimons@gmail.com), Guyot Hall 321B, Princeton, NJ 08544, and **Sofia C. Olhede**, Department of Statistical Science, London, WC1E 6BT, England. *Maximum-likelihood theory for the inversion of gravity and topography data to recover the elastic strength of a planetary lithosphere.*

The lithosphere is modeled using a differential equation characterized by a set of parameters, at least one of which, under the assumption of elastic behavior, is generally thought of as a proxy for its strength: the flexural rigidity (D), or, by extension, the elastic thickness. This lithospheric system then takes an input: topographic loading by mountain building and other processes, and maps it into an output: the gravity anomaly and the final, measurable, topography. Estimating D, most usually in the spectral domain, generally involves constructing summaries of gravity and topography. Both admittance and coherence are popular.Rarely, if ever, are lithospheric models found that satisfy both coherence and admittance to within their true error. We intend to abandon coherence and admittance studies for good, by proposing an entirely different method of estimating flexural rigidity, which returns it and its confidence interval, as well as tests for the suitability of the assumptions made along the way, and the possible presence of correlated loads and anisotropy in the response. The crux of the method is that it employs a maximum-likelihood formulation that remains very grounded in the data themselves and is formulated in terms of variables that do have a Gaussian distribution. (Received September 15, 2010)

1067-86-950 **Sean M Crowell*** (scrowell@ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019, and **Luther White** and **Louis Wicker**. *Estimation of Near Surface Wind Structures in Tornadic Vortices.*

Concentrated vortices in the atmosphere (such as tornados) constitute fluid mechanical phenomena that are fairly well understood qualitatively, and to less of an extent quantitatively. Field experiments in the past decade have sought a better understanding of such vortices using remote sensing technologies like radar in addition to standard measuring devices to provide a more complete picture of the atmosphere in the vicinity of severe rotation. Due to line of sight limitations on radar technology, the lowest few hundred meters of tornadic vortices are not measurable.

In this work, the authors investigate a methodology that incorporates measurements, simplified dynamics, and a tangential velocity model to estimate the quantitative and qualitative structure of the wind velocity in the near surface portion of the tornado. The sensitivity of the methodology to the amount of observable data is examined, and probabilistic interpretations are considered to account for the possibility of noisy data. (Received September 16, 2010)

1067-86-1669 **Beyza C Aslan*** (beyza.aslan@unf.edu), University of North Florida, Dept. of Math & Stat, 1 UNF Drive, Bldg 14/2731, Jacksonville, FL 32224, and **William Hager**. *Mathematical Methods for Modeling of Lightning and Thunderstorm Electrification.*

In climate change research and other areas concerning weather, lightning and the gases and energy it produces is a big interest. To be able to have better estimates related to anything lightning produces, one needs to understand lightning better. In our work, we try to accomplish two goals: Modeling the electric potential in the cloud and computing the charge density deposited by a flash. These two parameters are the two most important parameters in computing the lightning flash energy, which in turn provides other helpful information about lightning as well. In this talk, I will briefly discuss the mathematical methods we use to achieve these goals, and present some applications. (Received September 21, 2010)

1067-86-1887 **Bogdan G. Nita*** (nitab@mail.montclair.edu), Department of Mathematical Sciences, Montclair State University, 1 Normal Avenue, Montclair, NJ 07405, and **Ashley Ciesla** and **Christopher Smith**. *A one dimensional algorithm for seismic imaging and inversion: theoretical development and numerical tests.*

We present a method, derived from the inverse scattering theory, for geophysical imaging and amplitude correction from measured data. No knowledge about the medium under investigation is assumed. Although derived as a series, the algorithm is shown to converge to a closed form independent of the parameters involved in the problem. Analytic and numerical one dimensional examples show excellent results in finding both the location of interfaces and the amplitude of acoustic reflections. We model several one-dimensional earth configurations and show how the algorithm can find the precise location and a good estimate of the layers' parameters. Our tests include different number of layers, high/low contrasts, velocity inversions and noisy data. (Received September 22, 2010)

1067-86-2429 **Willi Freeden*** (freeden@mathematik.uni-kl.de), Geomathematics Group, University of Kaiserslautern, 67653 Kaiserslautern, RP. *Satellite Gravity Gradiometry (SGG)*

Satellite gravity gradiometry is a modern domain of studying the characteristics, the structure, and the variation process of the Earth's gravitational field. In 2009, the ESA began to realize the concept of SGG with the launch of the most sophisticated mission ever to investigate the Earth's gravitational field, viz. GOCE. The talk presents a mathematically reflected approach to SGG with strong interest in inverse modeling corresponding to the realistic geoscientific geometry (orbit as well as Earth's surface). (Received September 22, 2010)

90 ► Operations research, mathematical programming

1067-90-438 **Monaldo Mastrolili**, **Maurice Queyranne**, **Andreas S. Schulz**, **Ola Svensson** and **Nelson A. Uhan*** (nuhan@purdue.edu), School of Industrial Engineering, Purdue University, 315 N. Grant Street, Grissom Hall 308, West Lafayette, IN 47907. *Minimizing the sum of weighted completion times in a concurrent open shop.*

We study minimizing the sum of weighted completion times in a concurrent open shop environment. We show several interesting properties of various natural linear programming relaxations for this problem, including that they all have an integrality gap of 2. In addition, we propose a simple combinatorial 2-approximation algorithm that can be viewed as a primal-dual algorithm or a greedy algorithm that starts from the end of the schedule.

Finally, we show that this problem is inapproximable within a factor of $6/5 - \epsilon$ (or within a factor $4/3 - \epsilon$ if the Unique Games Conjecture is true) for any $\epsilon > 0$, unless P = NP. (Received September 03, 2010)

1067-90-554 **Bao Quang TRUONG*** (tqbao78@yahoo.com), 1401 Presque Isle Avenue, Marquette, MI MI 49855, and **Christiane Tammer** (christiane.tammer@mathematik.uni-halle.de). *Lagrange necessary conditions for Pareto minimizers in Asplund spaces and applications.*

In this talk, new necessary conditions for Pareto minimal points to sets and Pareto minimizers for constrained multiobjective optimization problems are established without both the sequentially normal compactness property and the asymptotical compactness condition usually imposed on closed and convex ordering cones. Our approach is based on a version of the separation theorem for nonconvex sets and the subdifferentials of vector-valued and set-valued mappings. Furthermore, applications in mathematical finance and approximation theory are discussed. (Received September 09, 2010)

1067-90-641 **Yuri Yatsenko*** (yyatsenko@hbu.edu). *Modeling of the optimal economic response to environmental adaptation.*

The environmental adaptation is the adjustment of economic system in response to observed or expected changes in the environment. We develop an optimization model to study rational environmental adaptation policies that compensate negative consequences of certain environmental hazards. The model is described as the optimal control of nonlinear integral equations. It distinguishes three categories of adaptation measures that (a) compensate the decrease of the environmental amenity value, (b) compensate the decrease of total productivity, (c) develop and introduce new hazard-protected capital and technology. The steady-state optimal balance among investment, consumption, and different categories of adaptation investments is analyzed. It appears that the environmental hazard and subsequent adaptation do not lead in the long run to a higher level of capital modernization compared to the benchmark case with no hazard. A synergism between productivity-related and amenity-related adaptation activities arises because the productivity-related adaptation positively impacts the economy and creates better possibilities for the amenity adaptation. (Received September 12, 2010)

1067-90-806 **S. Thomas McCormick*** (tom.mccormick@sauder.ubc.ca), 253 Main Mall, Vancouver, BC V6T 1Z2, Canada, and **Maren Martens** and **Britta Peis**. *Primal-Dual Algorithms for Weighted Abstract Flow and Weighted Abstract Cut Packing.*

Two attractive frameworks for combinatorial optimization problems with guaranteed integer optimal solutions are Hoffman's Weighted Abstract Flow model that packs abstract paths with supermodular weights satisfying a crossing axiom into elements, and Hoffman's Lattice Polyhedron model. When the lattice in this model is a clutter, Hoffman shows that these two models are blocking duals of each other by showing that the Lattice Polyhedron model effectively reduces to packing "cuts" in an abstract network with supermodular weights.

We show that a common algorithmic framework based on the Primal-Dual algorithm gives the first polynomial combinatorial algorithm for both problems. In each case we relax the problem by a scalar parameter to create an unweighted restricted subproblem of the same class. We develop algorithms to solve these restricted subproblems, and show that the parameter and solutions always take integer values. Then we can apply a standard scaling technique to make the algorithms weakly polynomial. These algorithms generalize previous algorithms by McCormick for unweighted abstract flow, and by Frank for monotone abstract cut packing. (Received September 15, 2010)

1067-90-809 **Gianpaolo Oriolo*** (oriolo@disp.uniroma2.it), Universita' di Roma Tor Vergata, Dipartimento Ingegneria dell'Impresa, via del Politecnico, 1, 00133 Roma, Italy, and **Yuri Faenza** and **Gautier Stauffer**. *An $O(n^3)$ algorithm for the weighted stable set problem on claw-free graphs.*

The maximum weighted stable set problem (MWSS) on a claw-free graphs is a generalization of the weighted matching problem. Sbihi and later Lovász and Plummer gave algorithms for the cardinality case of MWSS, while Minty solved the weighted version. The Minty algorithm was revised by Nakamura and Tamura and later simplified by Schrijver and can be implemented to run in time $O(n^6)$.

A deep decomposition theorem for claw-free graphs was recently introduced by Chudnovsky and Seymour. Later, Oriolo, Pietropaoli and Stauffer proposed a new approach to solve MWSS on graphs that admit a suitable decomposition. Unfortunately, it is not known any polytime algorithm to get the decomposition by Chudnovsky and Seymour.

In this talk, we show a new decomposition theorem for claw-free graphs and a $O(n^3)$ algorithm to obtain the decomposition. Our theorem is inspired by that by Chudnovsky and Seymour, but it is a stand-alone result that, even if much less detailed, is particularly useful for the MWSS problem. In fact, building upon a few other results from the literature, we show that we can solve the MWSS in claw-free graphs in $O(n^3)$ time, drastically improving upon previous known algorithms. Our algorithm also "provides" a pretty simple extended formulation for the problem. (Received September 15, 2010)

1067-90-887 **Sylvia Boyd**, School of Inf. Tech. and Engineering (SITE), University of Ottawa, Ottawa, Ontario K1N 6N5, Canada, **Satoru Iwata*** (iwata@kurims.kyoto-u.ac.jp), Research Institute for Mathematical Sciences, (RIMS), Kyoto University, Kyoto, 606-8502, Japan, and **Kenjiro Takazawa**, Research Institute for Mathematical Sciences, (RIMS), Kyoto University, Kyoto, 606-8502, Japan. *Finding 2-factors covering 3- and 4-edge cuts in bridgeless cubic graphs.*

A famous theorem of Petersen states that every bridgeless cubic graph contains a perfect matching, and hence a 2-factor. Then it is easy to see that such a graph has a 2-factor that covers all the 3-edge cuts. A recent paper of Kaiser and Skrekovski shows that every bridgeless cubic graph has a 2-factor that covers all the 3- and 4-edge cuts. In this talk, we provide an efficient algorithm to find such a 2-factor. The algorithm can be used as a preprocess of a simple 6/5-approximation algorithm for finding a minimum 2-edge-connected spanning subgraph in 3-edge-connected cubic graphs. (Received September 16, 2010)

1067-90-889 **Aliakbar Montazer Haghighi*** (amhaghighi@pvamu.edu), PO Box 519, MS 2225, Suite 310D, Priaire View, TX 77446. *Poisson Arrival, Single-Processor, Exponential General Bulk Processing [M/M(m, M)/1] and Splitting Queueing System: A Mathematical Model for a Personnel Hiring Process.* Preliminary report.

In this paper a hiring process with a limited number of vacant and possibly dual positions is mathematically modeled as a bulk-processing and splitting tandem queueing process. Electronically online applications that arrive according to a Poisson process will be stopped as soon as the number of needed positions is filled. The general bulk processing rule is used with minimum and maximum limits for a batch size. Processing of a batch and splitting are assumed exponential with different parameters. A system of four-dimensional difference equations is set up and is to solve to obtain the steady-state distribution of the number of applications in the system, as well as the mean total processing time. (Received September 16, 2010)

1067-90-998 **David Hartvigsen*** (Hartvigsen.1@nd.edu), Mendoza College of Business, University of Notre Dame, Notre Dame, IN 46556-5646, and **Yanjun Li** (Li14@purdue.edu), Krannert School of Management, Purdue University, West Lafayette, IN 47907. *Polyhedral and Algorithmic Results for 1-restricted Simple 2-matchings.*

A simple 2-matching in a graph is a subgraph all of whose nodes have degree 1 or 2. A simple 2-matching is called k-restricted if every connected component has $> k$ edges. These problems are related to the travelling salesman problem. We present a polynomial-time algorithm for finding maximum cardinality 1-restricted simple 2-matchings. We also consider the general weighted problem for 1-restricted simple 2-matchings for which we present a class of facets. For a special class of graphs, we show that these facets are sufficient to describe the polytope and can be used in a polynomial-time primal-dual algorithm. (Received September 17, 2010)

1067-90-1013 **R N Mohapatra*** (ramm@pegasus.cc.ucf.edu), Department of Mathematics, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816. *Generalized Invexity and Higher Order Duality for Variational Problems.*

In this paper we discuss Higher order duality of Mangasarian type and Mond-Weir type for nonlinear variational problems. Under generalized invexity assumption which compose the primal problem, we derive higher order duality results. we also consider problems with weak duality, strong duality and converse duality. We shall consider examples and counter examples in support of our investigation. (Received September 17, 2010)

1067-90-1054 **Illya V. Hicks*** (ivhicks@rice.edu), 6100 Main St., Houston, TX 77005. *Computing Matroidal Branchwidth.*

This talk gives a general overview of practical computational methods for computing branch decompositions and the branchwidth of matroids. The concept of branch decompositions and its related invariant branchwidth were first introduced by Robertson and Seymour in their proof of the Graph Minors Theorem and can easily be generalized for any symmetric submodular set function. Subsequently, branch decompositions have been shown to be useful for solving NP-hard problems modeled on graphs such as the traveling salesman problem and graph minor containment. Hence, computing branch decompositions of matroids may prove equally beneficial for solving NP-hard problems modeled on matroids. This talk is based on joint work with Jing Ma, Susan Margulies, Nolan McMurray, and Elif Ulusal. (Received September 17, 2010)

1067-90-1217 **Chandra Chekuri**, **Sanjeev Khanna**, **Loic Seguin-Charbonneau** and **Burce Shepherd*** (bruce.shepherd@mcgill.ca), Burnside Hall Room 1113, Math and Stats / McGill University, 805 Sherbrooke Street West, Montreal, Quebec H3A2k1, Canada. *Maximum Disjoint Paths and Flow-Cut Gaps.* Preliminary report.

We consider disjoint path problems in undirected graphs: we have a graph G and demand pairs $s_i t_i$, $i = 1, 2, ..., k$. A subset of the demands is *satisfiable* if there is a collection of edge-disjoint paths connecting the pairs for the given subset. In the maximization version we consider the problem of satisfying the maximum number of pairs possible. For directed graphs this is known to be hard to approximate to within (roughly) $\sqrt{n}$ factors. In planar graphs, however, one can achieve a constant factor bound if edge congestion of 4 is allowed. We outline this approach and show how congestion 3 can in fact be achieved. (Received September 20, 2010)

1067-90-1378 **Peh H. Ng*** (pehng@morris.umn.edu), Division of Science and Mathematics, University of Minnesota - Morris, 600, East 4th Street, Morris, MN 56267, and **Herve L. Kerivin** (kerivin@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634. *Maximum-Weight Connected-Subgraph Problems.*

Given a simple and connected undirected graph $G = (V, E)$ with a rational weight function on the edge set, the *Maximum Weight Connected Subgraph Problem* (MWCSP) consists of finding a connected subgraph of G induced by a subset of edges in such a way that the total weight of the edges in the subgraph is maximized. We show that (MWCSP) is an NP-Hard problem, and we also show that (MWCSP) is equivalent to the *Prize-Collecting Steiner Tree Problem* (PCSTP). We also present efficient or polynomial-time algorithms to solve (MWCSP) on subclasses of graphs. (Received September 20, 2010)

1067-90-1389 **Steven A Bleiler*** (bleilers@pdx.edu), Fariborz Maseeh Dept. of Math and Stat, P.O. Box 751, Portland, OR 97207-0751, **Yoko Nagase** (ynagase@brookes.ac.uk), Dept. of Economics and International Business, Business School, Oxford, England, and **Thomas Fielden** (tfielden@pdx.edu), Fariborz Maseeh Dept. of Math and Stat, P.O. Box 751, Portland, OR 97207-0751. *Modeling a Carbon Market Using an Engineering Approach: Blue Chips Turning Green.*

We give an introduction to a programming environment that computes the minimum compliance cost of GHG emissions control for states, regulated industries, and technology types. Unlike general equilibrium models requiring simplifications and behavioral assumptions, our compliance cost calculator follows an engineering approach. Developed for the real world regulatory environment, assumptions on data processing and procedures for optimization are "visible" to the users and are real time configurable. An implementation demonstrated herein takes publicly available information about prices and GHG abatement alternatives and combines it with a parameterized set of policy options. Users can then interactively apply or non-apply a variety of constraints and see an estimate of the expected minimum abatement cost along with a detailed "portfolio" of abatement activities expected over the policy period. While AB32 is used as an example to demonstrate how such implementations can assist policy makers and regulators by facilitating the exchange of information and increasing the understanding of the effect of a proposed regulation, the model and implementation are not bound to it. With appropriate data sets, both the model and implementation may be applied to any GHG abatement market. (Received September 20, 2010)

1067-90-1965 **Darin Mohr*** (dgmohr@math.uiowa.edu), 15 MacLean Hall, Department of Mathematics, The University of Iowa, Iowa City, IA 52242-1419. *Hybrid Runge-Kutta and Quasi-Newton Algorithms.*

Given a starting point, finding a local minimizer in unconstrained nonlinear optimization and a fixed point of a gradient system of ordinary differential equations (ODEs) are two closely related problems. Quasi-Newton algorithms are widely used in unconstrained nonlinear optimization while Runge-Kutta methods are widely used for the numerical integration of ODEs. In this work we consider hybrid algorithms combining search curves generated by low order implicit Runge-Kutta methods for gradient systems and quasi-Newton type updates of the Jacobian matrix such as the BFGS update. We have extended these ideas to the limited memory BFGS algorithm and we have examined the performance of the hybrid algorithms on a variety of problems. (Received September 22, 2010)

1067-90-2005 **Meike Niederhausen*** (niederha@up.edu), Department of Mathematics, 5000 N. Willamette Blvd., Portland, OR 97203, and **Gary Mitchell** (mitchelg@up.edu), Pamplin School of Business Administration, 5000 N. Willamette Blvd., Portland, OR 97203. *An Effective Method for Replenishing Items with Seasonal Intermittent Demand.*

We consider an important inventory management problem experienced by many retailers, wholesalers, and service operations. Specifically, we consider the problem of replenishing items characterized by non-stationary (seasonal) intermittent demand and address key operational questions inventory managers must answer. Given information about the likely time between demand events and size of the demand (in units), how should an inventory manager determine when and how much to order? Should an order be placed after every demand event? Should an order be placed if no demand event has occurred? We develop a new type of ordering policy that addresses these questions and use a "mixed" geometric probability distribution to model non-stationary demand inter-arrival times. Finally, we compare the performance of our algorithm to Croston's Method in terms of inventory levels and associated net profits and discuss implications for inventory managers. (Received September 22, 2010)

1067-90-2142 **Sarah A King*** (saking@ncsu.edu). *Sparsity Optimization with Applications in Bioscience.* Preliminary report.

There is increasing interest in applying sparsity optimization to bioscience applications. Use of this approach for data compression or parameter estimation eliminates the need for system reductions. We will develop a general formulation for sparsity optimization and then apply our formulation and numerical algorithms to bionetworks. (Received September 22, 2010)

1067-90-2390 **Leilani Hendrina Gilpin*** (lgilpin@ucsd.edu). *Realization Relationships Between Communication Models.* Preliminary report.

Distributed autonomous routing algorithms are used to reach a consistent, global solution after nodes iteratively and independently collect, process and share information. This work focuses on studying how the network-communication model affects algorithm convergence. By defining a formally defined taxonomy, the hope is to further analyze how the algorithm convergence properties of different models in the taxonomy are related, and gain intuition about families of networks that oscillate. (Received September 23, 2010)

1067-90-2415 **William Cook***, School of Industrial and Systems Enginnering, Georgia Tech, Atlanta, GA 30332-0205. *In Pursuit of the Salesman: Mathematics at the Limits of Computation.*

The traveling salesman problem is easy to state: given a number of cities along with the cost of travel between each pair of them, find the cheapest way to visit them all and return to your starting point. Easy to state, but difficult to solve. Despite decades of research, in general it is not known how to significantly improve upon simple brute-force checking. It is a real possibility that there may never exist an efficient method that is guaranteed to solve every instance of the problem. This is a deep mathematical question: Is there an efficient solution method or not? The topic goes to the core of complexity theory concerning the limits of feasible computation and we may be far from seeing its resolution. This is not to say, however, that the research community has thus far come away empty-handed. Indeed, the problem has led to a large number of results and conjectures that are both beautiful and deep, and on the practical side solution methods are used to compute optimal or near-optimal tours for a host of applied problems on a daily basis, from genome sequencing to arranging music on iPods. In this talk we discuss the history, applications, and computation of this fascinating problem. (Received September 23, 2010)

91 ► Game theory, economics, social and behavioral sciences

1067-91-153 **Qi Sun*** (sunq@lafayette.edu), Easton, PA 18042. *An Analysis of the U.S. Consumer Price Index –An Application of the ARMA and the GARCH Model.* Preliminary report.

The U.S. Consumer Price Index (CPI) is a time series measure of the price level of consumer goods and services. It measures a price change for a constant market basket of goods and services from one period to the next within the same area and serves as one of the most popular measures of inflation. This research analyzes the monthly U.S. CPI data for the past 30 years using the ARMA (Autoregressive Moving Average) model and the GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model. By investigating the cyclical return of the CPI using the ARMA model, we discovered that both previous returns and shocks have an impact on future returns. Specifically, the cyclical return in the previous month has a positive effect on the cyclical return for the next month and shocks in the previous three months have negative impacts on the next cyclical return. Through studying the volatility of the CPI using the GARCH model, we found out that both previous variance and shocks contribute positively to the future volatility, but previous variance plays a more important role. (Received July 28, 2010)

1067-91-234 **Karl-Dieter Crisman*** (karl.crisman@gordon.edu). *The Borda Count, the Kemeny Rule, and the Permutahedron.*

Whether we vote for one candidate out of many, or get to rank all of them, voting and choice theory often asks procedures to obey some 'fairness' criteria. One natural such criterion is 'reversal symmetry'; the Borda Count (similar to what is used in college football rankings) and Kemeny Rule are two well-known processes which fulfill this criterion *in addition to* other symmetries.

One can use the algebra of whatever symmetries one has to analyze choice procedures. It turns out that just as the symmetric group naturally encodes permutational symmetry, adding reversal symmetry can be represented by the symmetries of the *permutahedron* (and its representation theory).

In this talk, we use this algebra to find a direct connection between the Kemeny Rule and Borda Count. Namely, they turn out to be special cases of a new one-parameter family of choice procedures, all of which are maximally symmetric with respect to the permutahedron. (Received August 11, 2010)

1067-91-235 **Laura M. Smith*** (lsmith@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *An Agent-Based Approach to Modeling Gang Rivalries.* Preliminary report.

We propose an interacting particle model to simulate the creation of gang rivalries in the Hollenbeck policing district of eastern Los Angeles. Our model integrates data from the Los Angeles Police Department, geographic information, and behavioral dynamics suggested by the LAPD and the criminology community. The movement dynamics of agents are coupled to an evolving complex network of gang rivalries, which is determined by previous interactions among agents in the system. The knowledge of major highways, the Los Angeles River, and the locations of gangs' centers of activity influences the agents' motion. The number of agents in each gang reflects historical information from the LAPD. We use common metrics from graph theory to compare networks produced by our simulations to the network existing in the criminology literature. (Received August 11, 2010)

1067-91-310 **Kate Burgers***, Department of Mathematics, Harvey Mudd College, 301 Platt Boulevard, Claremont, CA 91711, and **Julianne Upton**, Department of Mathematics, Linfield College, 900 SE Baker Street, McMinnville, OR 97128. *Generating Artificial Social Networks.*

A method for generating undirected connected graphs using a modification of the traditional preferential attachment algorithm is presented. This new Mutual Neighbor Preferential Attachment (MNPA) method produces scale free networks with more realistic clustering coefficients than the traditional Barabási–Albert (BA) model. The MNPA method can be tuned to produce a network of a desired size and target clustering coefficient and thus it is a valuable new tool for Monte Carlo experiments with artificial social networks. (Received August 19, 2010)

1067-91-777 **David Zuckerman*** (diz@cs.utexas.edu), Department of Computer Science, University of Texas at Austin, 1616 Guadalupe, Suite 2.408, Austin, TX 78701. *Pseudorandom Financial Derivatives from Expander Graphs.*

Arora, Barak, Brunnermeier, and Ge showed that taking computational complexity into account, a dishonest seller could dramatically increase the lemon costs of a family of financial derivatives. We show that if the seller is required to construct derivatives of a certain form, then this phenomenon disappears. In particular, we define and construct *pseudorandom derivative families*, for which lemon placement only slightly affects the values of the derivatives. Our constructions use expander graphs and randomness extractors.

We study our derivatives in a more general setting than Arora et al. In particular, we analyze arbitrary tranches of the common collateralized debt obligations (CDOs) when the underlying assets can have significant dependencies. (Received September 14, 2010)

1067-91-1112 **Yuanying Guan*** (yguan@math.fsu.edu). *Agent-based Asset Pricing Dynamics with incomplete market in Lucas Framework.* Preliminary report.

Lucas asset pricing model has been a very popular model in financial economics during the past decade. In incomplete market, the general existence of equilibrium and Pareto-optimality allocations may not hold. With heterogeneous agents assumption, market dynamics towards optimal allocations are even more complicated. In this paper, we incorporate agents' prediction into price equilibrium searching process, derive market pricing dynamics and implement simulations on behavior of markets.

Under independent identical distributed returns, Duffie's discrete-time asset pricing theory could be applied to solve for single agent's optimal policy. With learning schemes, agents are able to update their forecasts about price and make following move in next period. Since agents have different risk aversions and updating rules, some interesting chaotic dynamics come up through agents' forecasting and trading. Dynamical analysis on these phenomena provides us a better understanding of the market.
(Received September 19, 2010)

1067-91-1304 **Maria C. Mariani*** (mathdept@math.utep.edu), 500 W. University Ave., Bell Hall 124, El Paso, TX 79968-0514, and **Emmanuel Ncheuguim**, **Ionut Florescu** and **Indranil Sen Gupta**. *Option Pricing With Transaction Costs And Stochastic Volatility.*

Option pricing with transaction coasts 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. Under suitable conditions, we prove the existence of strong solutions of the problem. We also study the Spherical Harmonics Approach. (Received September 20, 2010)

1067-91-1473 **William K Brayer*** (wbrayer@gmu.edu), 1741 sundance dr, Reston, VA 20194. *An Agent-Based Modeling Approach to Financial Markets.*

Standard financial models are inadequate because they make very strong assumptions about rationality and efficiency that imply a Gaussian distribution of price changes. Yet bubbles and crashes frequently occur: thus conventional models severely underestimate the risk of extreme events in financial markets. The standard models use geometric Brownian motion to simulate the evolution of an asset price p over a timestep h via

$$p(n+1) = p(n)\exp(\sqrt{h}\eta - \frac{h}{2})$$

where $\eta \sim N(0,1)$.

We replace this pricing formula with

$$p(n+1) = p(n)\exp(\sqrt{h}\eta - \frac{h}{2} + \kappa\Delta\sigma(n))$$

where the additional term $\kappa\Delta\sigma(n)$ corresponds to changes in demand for the asset amongst M agents who are simulated directly.

Using simple rules, the market generates internal dynamics that correspond to the gradual formation of price bubbles followed by rapid crashes that closely resemble those seen in real financial markets (note that such internal effects are explicitly ruled out in the standard model).

We use this model to test a variety of trading rules germane to technical analysis. We show that technical analysis can produce excess returns and that herding may account for this phenomenon. (Received September 21, 2010)

1067-91-1559 **Arash Enayati Khorzoghi*** (aenayati@qatar.cmu.edu), P.O. Box 24866, Doha, Qatar. *Nash equilibria in a one-dimensional dispersion game.*

We study a one-dimensional, multi-player game in which player i plays the game by choosing an integer a_i and judges the results by a utility function $u_i(a_i) = -|a_i - \overline{a}| - 1.5 \cdot \sum_{j\neq i} \delta(a_i, a_j)$, where $\overline{a}$ is the arithmetic mean of all players' choices and δ is a delta function. This utility function measures how fashionable player i's choice is (proximity to the mean) and how unique s/he is in making their choice. We prove that this game always has at least one Nash equilibrium when number of players is greater than zero, and derive necessary and sufficient conditions for an outcome to be a Nash equilibrium. Moreover, we describe an algorithm with complexity $O(n^2)$ to generate a Nash equilibrium outcome for any number ($n > 0$) of players. (Received September 22, 2010)

1067-91-1721 **Arjun Sanghvi*** (asanghvi@gmu.edu). *A Stability Study of Asset Price Equilibrium Models.* Preliminary report.

A previously developed heterogeneous agent model is used to simulate the price of a financial asset and successfully captures statistical properties standard to actual financial data. These stylized facts include: volatility clustering, fat tail distributions, and power law decay of price changes. Such properties are often absent from models that implement the neoclassical assumptions of Economics. These neoclassical equilibrium models are derived from geometric Brownian motion with drift:

$$y(t) = y_0 e^{(r - \frac{1}{2}\sigma^2)t + \sigma B_t}$$

The proposed model invokes price thresholds to simulate agent behavior over a long timescale. Agents often act, rationally or irrationally, based on the choices of others in the system - a characteristic called herding.

By introducing adjustable parameters to the Efficient Market Hypothesis (EMH) baseline model, we control and thereby determine the effect of such variables on the market dynamics. Using a bifurcation parameter we analyze the stability of the equilibrium model and find the point at which it becomes unstable. We find that for low levels of herding, the EMH becomes unstable; and as the level of herding is increased, the model achieves the most important stylized facts. (Received September 21, 2010)

1067-91-1819 **John M Cleveland*** (jcleve72@gmail.com), PA , and **Azmy S Ackleh**. *Evolutionary Game Theory on Measure Spaces.*

This is part of a work attempting to find a unified theory for fully nonlinear evolutionary game theoretic models. Here we deal with asymptotic analysis. To study the long term behavior of replicator mutator dynamics, a dynamical system on the state space of finite signed Borel measures along with a certain notion of weak or "generalized" asymptotic limit are shown essential.

We show the population to be permanent and for pure replicator dynamics a Dirac mass centered on the fittest trait is a globally attracting equilibrium (Continuous Stable Strategy). For discrete strategy spaces pure replicator dynamics and small perturbations thereof also yield globally asymptotically stable equilibria. Biology, Economics, Network and Social Science, are all fruitful fields of application. (Received September 21, 2010)

1067-91-1884 **Emmanuel Kengni Ncheuguim*** (emmanou@nmsu.edu), 509 Sweet Ave, Las Cruces, NM 88001, and **Maria Mariani**. *Options pricing with transaction costs and stochastic volatility.* Preliminary report.

Option pricing with transaction coasts 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 and extend it to the case where the volatility is stochastic. Under suitable conditions, we prove the existence of strong solutions of the problem. (Received September 22, 2010)

1067-91-1919 **Yilun Dong*** (dongyilun@gmail.com), 500 College Avenue, Swarthmore, PA 19081, and **Ted Theodosopoulos** (ttheodosopoulos@saintannsny.org), 60 Wyckoff Street, Brooklyn, NY 11201. *Martingale properties of the wealth process in a spin market model.* Preliminary report.

We apply a spin model for market microstructure and define a wealth process as a stochastic integral. In our wealth process, agents make decisions under two competing objectives: being in the majority in their local random network neighbourhood (herding behaviour, trend following) and being in the global minority (contrarian trading). We analyse the effect of the volatility parameter λ and the coupling constant between local and global interactions α on the martingale properties and asymptotic stability of the resulting wealth process. In particular, we identify four distinct regimes and we arrive at a complete classification of the dynamic behaviour for our model market in the case of small neighbourhoods. We also provide a conjecture for this classification in the general case. (Received September 22, 2010)

1067-91-2021 **Stephen J. Young*** (s7young@math.ucsd.edu) and **Fan Chung**. *Braess's Paradox in Random Graphs.*

Braess's paradox, in its original context, is the counter-intuitive observation that, without lessening demand, closing roads can improve traffic flow. With the explosion of distributed (selfish) routing situations understanding this paradox has become an important concern in a broad range of network design situations. However, the previous theoretical work on Braess's paradox has focused on "designer" graphs or dense graphs, which are unrealistic in practical situations. In this work, we exploit the expansion properties of Erdős-Rényi random graphs to show that Braess's paradox occurs when $np \geq c \log(n)$ for some $c > 1$. (Received September 22, 2010)

1067-91-2128 **Jim C. Manning*** (manninjc@email.sc.edu) and **Margaret Cozzens**. *Cascading Behavior in Networks: A Game Theory Approach to Modeling Voting Behavior.* Preliminary report.

This project is at the nexus of applied math and political science, using techniques from graph theory and game theory to model recent Congressional and Presidential elections. Using CNN exit poll data in which voters self identified as liberal, moderate or conservative, we represented the electorate as a graph, where individuals were depicted by vertices and those voters with similar ideologies were connected with edges. Obama and McCain could then choose marketing strategies, where their success rate would be determined by the percentages obtained from the exit polls. Our model showed Obama was best to run a moderate campaign, and that he could expect to win with 53% of the popular vote. He actually had 52.9%. However, by allowing each candidate multiple rounds of marketing (with the option to change strategies) the updated model indicated that McCain could have won, had he run a more moderate campaign. Similarly modeling the percentage of the national vote share received by Congressional candidates in the last three cycles also closely followed the observed results. (Received September 22, 2010)

1067-91-2247 **Richard E Niemeyer*** (richard.niemeyer@gmail.com), University of California, Riverside, Department of Sociology, 900 University Ave., Riverside, CA 92507. *"Graphs, Dynamical Systems, Fractals: A Heuristic Framework For Modeling the Structure and Dynamics of Complex Interactions Across Multiple Levels of Analysis"*. Preliminary report.

With increasing regularity, researchers across the natural and social sciences are employing network analysis, dynamical systems theory, and fractal geometry to model complex dynamics. As of yet though, attempts to combine the unique insights provided by each of the three mathematical tool-sets into a single analytical model are incomplete.In this talk, we will present a heuristic framework capable of accomplishing such a task. To demonstrate the consequence of this framework, we will discuss its applicability in examining of the biological foundations of human consciousness, the rise and fall of AfroEurasian Empires, and the spread of infectious diseases. (Received September 22, 2010)

92 ► Biology and other natural sciences

1067-92-9 **Andrea L Bertozzi*** (bertozzi@math.ucla.edu), Department of Mathematics, University of California, Los Angeles, 520 Portola Plaza, Los Angeles, CA 90095. *Self-organization in human, biological, and artificial systems.*

I will discuss recent work on self-organization in complex systems with a focus on human and biological models as well as artificial systems. Specific case studies include (a) the formation of crime hotspots in urban settings and the mechanisms that lead to such behavior (b) collective motion of swarms, flocks, and schools in animal populations and (c) cooperative control of robotic vehicles using models motivated by biological examples. Such research problems have led to interesting work and open problems for the mathematics community, bringing together ideas from different research areas including dynamical systems, stochastic processes, statistical sampling, bifurcation theory, graph theory, and partial differential equations. (Received September 20, 2010)

1067-92-48 **Marco A Huertas** (huertas.marco@gmail.com) and **Gregory Douglas Smith*** (greg@as.wm.edu), Department of Applied Science, McGlothlin-Street Hall, Rm 305, Williamsburg, VA 23185. *Modeling the stochastic dynamics of localized calcium elevations and whole cell calcium responses.*

Localized Ca elevations known as Ca puffs and sparks are cellular signals that arise from the cooperative activity of clusters of inositol 1,4,5-trisphosphate receptors and ryanodine receptors on the surface of the endoplasmic reticulum or sarcoplasmic reticulum. When Markov chain models of intracellular Ca regulated Ca channels are coupled via a mathematical representation of a Ca microdomain, simulated Ca release sites may exhibit the phenomenon of stochastic Ca excitability. Such mathematical models provide insight into the relationship between single-channel kinetics and the statistics of puff/spark duration, and clarify the role of stochastic attrition, Ca inactivation, luminal depletion, and allosteric interactions in the dynamics of puff/spark termination. The stochastic dynamics of local Ca is an important aspect of excitation-contraction coupling in cardiac myocytes, where sarcoplasmic reticulum Ca-induced Ca release is locally controlled by trigger Ca influx via L-type channels of the plasma membrane. A recently developed whole cell modeling approach is able to avoid the computationally demanding task of resolving spatial aspects of global Ca signaling, while accurately representing heterogeneous local Ca signals in a population of Ca release units. (Received June 22, 2010)

1067-92-141 **Hayley M Belli*** (hbelli@uoregon.edu), **Jay R Walton** and **May Boggess**. *A Mathematical Model of the Effects of Antioxidants on Atherosclerotic Lesion Growth.*

Atherosclerosis is a form of cardiovascular disease characterized by an accumulation of cellular debris and inflammation in the innermost layer of the arterial wall. Statin drugs have been the primary method for treating atherosclerotic lesions, but recent research suggests that lifestyle changes, in particular consuming a diet rich in antioxidants, may be equally effective at preventing the process of atherogenesis. In this paper, two mathematical models are developed to simulate the effects of antioxidants on lesion regression and the reaction-diffusion process of atherosclerosis at the biological level. The first model is a system of six ordinary differential equations, and the second is a one-dimensional spatial model composed of partial differential equations. The ODE model helps to define a healthy state through the computation of equilibrium values. Meanwhile, the PDE system adopts the form of a discrete Taylor series approximation in order to model atherosclerosis under distinct parameters and

boundary conditions. To avoid a numerical instability, a finite difference scheme is used to develop a diffusion coefficient for the model. These mathematical equations supply cardiologists with means for simulating and numerically analyzing various lesion regression scenarios. (Received July 27, 2010)

1067-92-142 **Patrick Thomas Davis*** (pdavis16@emich.edu), 2363 Geoffry, Warren, MI 48092, and **May Boggess** (may.boggess@gmail.com) and **Jay Walton** (jayrwalton@gmail.com). *Modeling the Effects of Cannibalistic Behavior in Zebra Mussel (Dreissena polymorpha) Populations.*

The threat of invasive species has increased with the expansion of global transportation. In the United States, zebra mussels became a problem by the early 1990's when they were introduced by ballast water into Lake St. Clair in 1988. In 2007, a new deterministic discrete-time model for zebra mussel populations was proposed by Casagrandi. We show how this model produces periodic, stable, and chaotic population patterns. In addition, a parametric analysis corrects some results of Casagrandi concerning the effect of changes in the adult cannibalistic behavior through filter-feeding. Finally, a new stochastic continuous-time model is proposed, abstracted from the Casagrandi model and implemented via the Gillespie algorithm. (Received July 27, 2010)

1067-92-149 **Gregory Alan Backus*** (greg.backus@gmail.com), PO Box 500, Annandale-on-Hudson, NY 12504, and **Albert Boggess**, **May Boggess** and **Kirsten Bohn**. *A Categorization of Brazilian Free-Tailed Bat (Tadarida brasiliensis) Chirps.*

Male Brazilian Free-tailed Bats (*Tadarida brasiliensis*) attract mates and defend territory using multi-phrase songs that follow a structured set of rules. A subjective view of their spectrograms shows similarity and dissimilarity between the chirps (a syllable within the song) of different males. We developed an algorithm to characterize the shapes of these chirps. The discrete Fourier transform allowed us to focus on frequency information while a four level Daubechies 2 wavelet decomposition allowed us to focus on both frequency and time. For comparison, we compressed large data vectors into a single data point using multidimensional scaling. Segmenting chirps, to further emphasize ranges of time and frequency, gave categorizations that most closely resemble the subjective groupings. (Received July 27, 2010)

1067-92-163 **Gabriel T Davis*** (davisg@carleton.edu), 300 North College Street, Northfield, MN 55057, and **Jay Walton** (jwalton@math.tamu.edu) and **May Boggess** (mboggess@math.tamu.edu). *Mathematical models for the effect of transmission-blocking vaccines on malaria.*

Malaria is an enormous global health problem, resulting in 3 million deaths each year. It is also both a major cause and an effect of poverty. New transmission-blocking vaccines (TBVs) which prevent the transmission of the parasite from vaccinated humans to susceptible mosquitoes, may offer new hope for the eradication of malaria in communities in Africa and elsewhere. However, mathematical models of the vaccine's effects are needed. We present an ODE model that can be generalized to show the effect of the vaccine on small isolated communities, and assess its effectiveness as an eradication tool. We also present a complementary stochastic model. From the model we conclude that TBVs alone are unlikely to be a solution, but may form part of a long-term, multi-prong eradication effort. The stochastic model allows assessment of the long-term usefulness of the model by giving an estimate of the variance over time. (Received July 28, 2010)

1067-92-179 **Amalie McKee*** (axm358@case.edu). *Disease Dynamics in Honeybee Populations.* Preliminary report.

The recent epidemic of Colony Collapse Disorder has made it clear how dependent we are on bee populations. We explore disease dynamics among hive insects and potential treatment methods, examining changes in long term behavior. (Received July 28, 2010)

1067-92-187 **Eric Todd Quinto*** (todd.quinto@tufts.edu), Tufts University, Department of Mathematics, 503 Boston Ave., Medford, MA 02155, **Andreas Rieder** (andreas.rieder@kit.edu), Karlsruhe Institute of Technology, Kaiserstrasse 93, D-76133 Karlsruhe, Germany, and **Thomas Schuster** (schuster@hsu-hh.de), Helmut Schmidt Universitaet, Fachbereich Maschinenbau, Holstenhofweg 85, D-22043 Hamburg, Germany. *Local Inversion of the Sonar Transform Regularized by the Approximate Inverse.*

A new reconstruction method is given for the spherical mean transform with centers on a plane in $\mathbb{R}^3$ which is also called the Sonar transform. The data are local in the sense that the centers and radii are in a compact set, and the operator is local because, to reconstruct at $\mathbf{x}$, one needs only spheres that pass near $\mathbf{x}$. The microlocal properties of the reconstruction operator, including its symbol as a pseudodifferential operator, are given. The method is implemented using the approximate inverse, and reconstructions are given. They are evaluated in light of the microlocal properties of the reconstruction operator. (Received July 29, 2010)

1067-92-188 **Jana Gevertz*** (gevertz@tcnj.edu), Department of Mathematics & Statistics, The College of New Jersey, PO Box 7718, Ewing, NJ 08628-0718. *Predicting Tumor Response to Vascular-Targeting Therapies using a Mathematical Model.*

A relatively novel use of mathematics in the field of cancer research is in drug discovery process. In this talk, I will briefly describe a validated hybrid cellular automaton model of tumor growth and I will illustrate the models ability to predict the anti-tumor activity of several vascular-targeting compounds of known efficacy. Following model validation, I will demonstrate how the model can be used to make predictions about clinically-untested treatment protocols. (Received July 29, 2010)

1067-92-201 **Eva M Strawbridge*** (emstrawb@math.uchicago.edu), University of Chicago, Deparment of Mathematics, 5734 South University Ave., Chicago, IL 60637. *Compatibility of Slender Body Theory and Surface Traction.*

I will present a careful argument for the compatibility of slender body theory, specifically Kirchhoff rod theory, and surface traction due to viscous drag from a Stokes flow. This is the first careful analysis of this theory and will show the precise case when the two theories are compatible and when they are not. This work has direct applications to mathematical biology, in particular DNA mechanics and dynamics and flagellar motion of sperm and microorganisms. (Received August 02, 2010)

1067-92-275 **Lakshmi Chandrasekaran*** (chandrasekaran.lakshmi@gmail.com), 2020 Gravier street, New Orleans, LA 70112. *Stability of two cluster solutions in pulse coupled networks of neural oscillators.*

We study two reciprocally coupled clusters of pulse coupled oscillatory neurons. Using mathematical modeling and numerical simulations we prove rigorously the stability of the two cluster solution and show how reciprocal coupling can stabilize synchrony within clusters that cannot synchronize in isolation. These results suggest a mechanism by which reciprocal coupling between brain regions can induce local synchronization via the network feedback loop. (Received August 15, 2010)

1067-92-276 **Manfred Denker*** (denker@math.uni-goettingen.de). *Random dynamical systems and an application to self-organized criticality in neural data.*

We give a brief introduction to discrete time random dynamical system and explain Levina's model (2008) to study the avalanche size in complete neural networks of firing ions. In particular, we discuss Levina's result that its probability satisfies a power law in the critical case. (Received August 15, 2010)

1067-92-307 **Jemal S Mohammed-Awel*** (jmohammedawel@valdosta.edu), P.O.Box 5743, Valdosta, GA 31603, and **John Bantle**, **Aaron Festinger**, **Ryan Klafehn**, **Hee-Joon Jo** and **John Ringland**. *Boundaries of Sustainability in Simple and Elaborate Models of Agricultural Pest Control with a Pesticide and a Nontoxic Refuge.* Preliminary report.

In two models of pest control using a pesticidal crop along with a non-pesticidal refuge to prevent the development of resistance, we numerically compute the bifurcations that bound the region in parameter-space where control is sustainable indefinitely. An exact formula for one of the bifurcation surfaces in one of the models is also found. One model is conceptual and as simple as possible. The other is realistic and very detailed. Despite the great differences in the models, we find the same distinctive bifurcation structure. We focus on the parameters that determine: (i) the restriction of pest exchange between the crop and the refuge, which we call screening the refuge, and (ii) the recessiveness of the resistance trait. The screened refuge technique is seen to work in the models up to quite high values of the fitness of resistant heterozygotes, i.e., even when resistance is not strongly recessive. (Received August 18, 2010)

1067-92-317 **Chad M. Topaz*** (ctopaz@macalester.edu), Macalester College, Deptartment of Mathematics, Statistics, & CS, 1600 Grand Ave., St. Paul, MN 55105, and **Andrew J. Bernoff** (ajb@hmc.edu), Harvey Mudd College, Dept. of Mathematics, 301 Platt Blvd., Claremont, CA 91711. *Asymptotic dynamics of attractive-repulsive swarms.*

We classify and predict the asymptotic dynamics of a class of swarming models. The model consists of a conservation equation in one-dimension describing the movement of a population density field. The velocity is found by convolving the density with a kernel describing attractive-repulsive social interactions. The kernel's first moment and its limiting behavior at the origin determine whether the population asymptotically spreads, contracts, or reaches steady-state. For the spreading case, the dynamics approach those of the porous medium equation. The widening, compactly-supported population has edges that behave like traveling waves whose speed, density and slope we calculate. For the steady states we calculate analytic expressions for the swarm density when the kernel is a Morse potential, a common model of attraction and repulsion. For the contracting case, the dynamics of the cumulative density approach those of Burgers' equation. We derive an analytical upper bound for the finite blow-up time after which the solution forms one or more δ-functions. (Received August 20, 2010)

1067-92-365 **Roberto Munoz-Alicea*** (romual2002@hotmail.com), 1112 Columbine Ct. Apt. 2, Fort Collins, CO 80521. *A Mathematical Model for Active Transport of Gag Protein in the Cytoplasm.* Preliminary report.

We present a mathematical model for the intracellular transport of the Gag protein, a major structural component of the HIV-1 viral capsid. The model includes both diffusion and active transport mechanisms. We assume that the active transport takes place along microtubules. We use characteristic finite element methods to carry out numerical simulations. Numerical results are consistent with biological experimental data.

This research was done in collaboration with Dr. James Liu and Dr. Chaoping Chen at Colorado State University, Fort Collins. (Received August 27, 2010)

1067-92-433 **Bonni J Kealy*** (bkealy@math.wsu.edu), Department of Mathematics, Washington State University, Pullman, WA 99163, and **David J Wollkind**, Department of Mathematics, Washington State University, Pullman, WA 99163. *A One-Dimensional Nonlinear Stability Analysis of Vegetative Pattern Formation for an Interaction-Diffusion Plant-Surface Water Model System in an Arid Flat Environment.*

The development of spontaneous stationary vegetative patterns in an arid flat environment is investigated by means of a one-dimensional weakly nonlinear diffusive instability analysis applied to the appropriate model system for this phenomenon. In particular, that process can be modeled by a partial differential interaction-diffusion equation system for the plant biomass density and the surface water content defined on an unbounded flat spatial domain. The main results of this analysis can be represented by closed-form plots in the rate of precipitation versus the specific rate of plant density loss parameter space. From these plots, regions corresponding to bare ground, striped vegetative patterns, and homogeneous distributions of vegetation, respectively, may be identified in this parameter space. Then those theoretical predictions are compared with both relevant observational evidence involving tiger bush patterns and existing numerical simulations. (Received September 20, 2010)

1067-92-461 **Frederic Mazenc** (Frederic.Mazenc@lss.supelec.fr), Projet INRIA DISCO, CNRS-Supelec, 3 rue Joliot Curie, 91192, Gif-sur-Yvette, France, and **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, 303 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803-4918. *Recent Results on Control Problems for Chemostats.*

I will summarize my joint research with Frederic Mazenc on feedback stabilization of coexistence behaviors in chemostats with multiple species and one limiting substrate. Our results are largely based on Lyapunov functions, and they can determine the effects of actuator errors, feedback delays, and model uncertainty. (Received September 11, 2010)

1067-92-471 **Ye (Alice) Tian*** (ytian@math.wsu.edu), Department of Mathematics, Washington State University, P.O.Box 643113, Pullman, WA 99164, and **Christopher Deutsch** and **Bala Krishnamoorthy**. *Optimized Scoring Function to Predict Solubility Mutagenesis.*

Background: Mutagenesis is commonly used to engineer proteins with desirable properties not present in the wild type (WT) protein, such as increased or decreased stability, reactivity, or solubility. Experimentalists often have to choose a small subset of mutations from a large number of candidates to obtain the desired change, and computational techniques are invaluable to make the choices. Results: We use concepts from computational geometry to define a three body scoring function that predicts the change in protein solubility due to mutations. The scoring function captures both sequence and structure information. By exploring the literature, we have assemble a substantial database of 137 single- and multiple-point solubility mutations. Our database is the largest such collection with structural information known so far. We optimize the scoring function using linear programming (LP) methods to derive weights based on training. We compare the LP method to the standard machine learning techniques of support vector machines (SVM) and the Lasso. Using statistics for leave-one-out (LOO), 10-fold, and 3-fold cross validations (CV) for training and prediction, we demonstrate that the LP method performs the best overall. For the LOOCV, the LP method has an overall accuracy of 81%. (Received September 05, 2010)

1067-92-490 **Frederic Y. M. Wan*** (fwan@uci.edu), Department of Mathematics, University of California, Irvine, Irvine, CA 92697-3875. *Linear PDE Models of Neurons with Random Excitations*.

Neuronal models, including Rall's equivalent cylinder for cable neurons and its variants, are often in terms of linear PDE. For neuron subject to random excitations, the solution may be in the form of a Green's function representation. Statistical properties (mean, correlations, higher order moments) can be determined from the corresponding measures of the input by the expectation of combinations of the Green's function representation. In practice, Green's functions are often not available analytically. To compute the needed Green's function numerically and then evaluate the multiple integrals involved in the desired statistics require excessive computing. Equally serious is the huge storage requirement for a function of four or more variables that may be impractical for the needed accuracy. While Monte Carlo simulations are possible, determining statistical properties of interest by solving directly some deterministic problems in PDE (for which there is a large body of knowledge on their numerical solutions) is desirable. This paper 1) develops such a method; 2) applies it to several problems in biology, and 3) shows how the method takes advantage of recent efficient algorithms that reduce storage requirements by orders of magnitude. (Received September 06, 2010)

1067-92-498 **Peter J. Thomas*** (pjthomas@case.edu), Department of Mathematics, Case Western Reserve University, 10900 Euclid Avenue, Cleveland, OH 44106. *Synchronization of periodically forced Ornstein Uhlenbeck processes with reset.* Preliminary report.

Ornstein Uhlenbeck processes with fixed threshold and reset appear in a neuroscience context as *noisy integrate-and-fire models*:

$$\begin{aligned} T_0 &= t_0 \\ dX(t) &= (-X + \alpha + \beta h(t))\,dt + \sigma\,dW(t), \qquad T_k \le t < T_{k+1} \\ T_{k+1} &= \inf\{t | \mathcal{S}(T_k, t) \ge \theta\} \\ X(T_{k+1}) &= x_0, \end{aligned}$$

where T_k is a sequence of firing times, $X(t)$ is a strong Markov process, t_0, x_0, α, β, θ and σ are (fixed, deterministic) constants, $\mathcal{S}(u,t) = \sup\{X(s)|s \in (u,t]\})$, W is a standard Brownian motion and $h(t)$ is a periodic forcing function. Keener, Hoppensteadt and Rinzel (1981) exhaustively classified phase locking in the case $h(t) = \sin(\omega t)$ and $\sigma = 0$. Wan and Tuckwell (1982) obtained analytic expressions for the mean and variance of the first passage time in the case $\beta = 0$. Under suitable assumptions on the constants we prove the existence of a unique invariant measure characterizing the distribution of the firing time phases T_k mod T. (Received September 07, 2010)

1067-92-500 **Christoph Borgers*** (cborgers@tufts.edu), Department of Mathematics, Tufts University, Medford, MA 02421. *Gamma-generating networks with inhibitory cells that do not participate in the rhythm.* Preliminary report.

Gamma (30-80 Hz) oscillations in the hippocampus and neocortex are thought to come about from the interaction of pyramidal cells and a specific class of inhibitory neurons, the parvalbumin-positive basket cells. The firing of many other types of inhibitory neurons in the brain is modulated only weakly by ongoing gamma oscillations. The work presented here is part of a larger project in which we try to understand the roles of some of these cell types in gamma oscillations.

A constant low-level bath of inhibition affecting the gamma-generating networks facilitates the formation of gamma oscillations and amplifies winner-take-all competition among pyramidal cells. I will explain why and in which sense this is so by analyzing model problems, and illustrate the effects by numerical examples. These observations support the suggestion that CCK-positive basket cells may play a role in thresholding pyramidal cells during gamma oscillations (Tukker et al, J. Neurosci. 2007).

I will then present a numerical study of the effects of random fluctuations in the strength of the bath of inhibition. Stochasticity appears to soften the thresholding. It also introduces random fluctuations in the gamma period, thereby making the behavior of the gamma-generating model networks more realistic. (Received September 07, 2010)

1067-92-516 **Folashade B. Agusto*** (fbagusto@gmail.com), NIMBioS, University of Tennessee, 1534 White Avenue, Knoxville, TN 37996, and **Suzanne Lenhart** (lenhart@math.utk.edu), NIMBioS, University of Tennessee, 1534 White Avenue, Knoxville, TN 37996. *Optimal Control of the Spread of Malaria Super-Infectivity.* Preliminary report.

Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected mosquitoes, about half the world population is at risk of infection. In this paper, a deterministic model for malaria transmission, incorporating the re-infection of symptomatic individuals, a phenomenon known as superinfection is presented. Qualitative analysis of the model reveals the presence of backward bifurcation a phenomenon where stable disease free equilibrium co-exists with a stable endemic equilibrium when the associated reproduction threshold is less than unity. Optimal control theory is then applied to the model to study the time dependent treatment efforts to minimize the infected while keeping the implementation cost at a minimum. (Received September 08, 2010)

1067-92-525 **Trachette L. Jackson*** (`tjacks@umich.edu`), Department of Mathematics, University of Michigan, 530 Church Street, Ann Arbor, MI 48109-1043. *The Evolution of Spatio-Temporal Models of Tumor Angiogenesis.*

Motility – random, directed and collective – is a fundamental property of cells. Coordinated motility of endothelial cells that reside on the inner surface of blood vessels leads to a critical bifurcation point in cancer progression: tumor angiogenesis. Successful angiogenesis is a consequence of integration across multiple levels of biological organization, and several temporal and spatial scales. A major challenge facing the cancer research community is to integrate known information in a way that improves our understanding of the mechanisms driving tumor angiogenesis and that will advance efforts aimed at the development of new therapies for treating cancer. In this talk, the evolution of spatio-temporal mathematical models of tumor angiogenesis will be explored and recent advances will be highlighted. (Received September 08, 2010)

1067-92-541 **John G. Alford*** (`jalford@shsu.edu`), Lee Drain Building, P.O. Box 2206, Huntsville, TX 77341, and **William I. Lutterschmidt**. *Modeling Energetic and Theoretical Costs of Thermoregulatory Strategy.*

Poikilothermic ectotherms are those animals whose body temperatures fluctuate with ambient environmental temperatures. Some ectotherms have evolved behaviors to maintain or thermoregulate their body temperature around a preferred or "set point" temperature. Thermoregulatory behaviors may range from body positioning to optimize heat gain to shuttling among preferred microhabitats. We have modeled movement and shuttling behavior within a habitat as a biased random walk. We quantify the required movements and potential energetic cost for a timber rattlesnake to actively thermoregulate rather than thermoconform using a model parameter that forces the snake to precisely maintain its preferred body temperature. In addition, we investigate the behavioral life histories of sit-and-wait versus active foraging behaviors and their associated thermoregulatory strategies by quantifying the benefits and the metabolic and locomotory costs of thermoconforming versus actively thermoregulating. (Received September 08, 2010)

1067-92-545 **Azmy S. Ackleh*** (`ackleh@louisiana.edu`), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, **Ross A. Chiquet**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, and **Pei Zhang**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010. *A Stage-Structured Dispersal Model with Constant and Periodic Environments.*

We study a discrete juvenile-adult model which describes the dynamics of a population that reproduces and disperses between two patches constantly or seasonally. When breeding and dispersal rates are constant, the model has a unique interior equilibrium that is globally attractive, provided the net reproductive number is greater than one. If net reproductive number is less than one, then the extinction equilibrium is globally asymptotically stable. When breeding and dispersal rates are periodic of period two, the extinction equilibrium is globally asymptotically stable if the net reproductive number is less than one. If the net reproductive number is greater than one, then there exists a unique globally attractive periodic solution. We then use bifurcation diagrams to compare constant and seasonal breeding strategies, to explore the effects of different birth and dispersal periodicities and to understand the influence of strong nonlinearities on the dynamics of the model. (Received September 08, 2010)

1067-92-570 **Paul Leonard Salceanu*** (`salceanu@louisiana.edu`), 217 Maxim D. Doucet Hall, P.O.Box 41010, Lafayette, LA 70504. *Uniform Persistence in Discrete and Continuous Non-autonomous Dynamical Systems with Application to an Epidemic Model of an Amphibian Population.* Preliminary report.

This is an extension of the work of Salceanu and Smith (2009), where boundary attractors for autonomous dynamical systems on the positive orthant of $\mathbb{R}^m$, generated by maps, were characterized as *uniformly weak repellers*, in order to obtain conditions for uniform persistence. Here we take an unified approach, for both discrete and continuous time non-autonomous systems. The main assumption is that a nontrivial compact positively invariant set M exists on a bounding hyperplane. We show that when this boundary set has certain repelling properties, uniform persistence for the complementary dynamics is obtained. When the system is periodic, and every solution on M is attracted to a periodic orbit, the repelling properties of M are expressed in terms of spectral radii. We apply these results to an SI model of an amphibian population, with periodic coefficients, and obtain conditions for uniform persistence of the disease. (Received September 09, 2010)

1067-92-605 **Azmy S Ackleh** and **Robert J Sacker*** (rsacker@usc.edu), 3620 S. Vermont Ave., KAP 104, Los Angeles, CA 90089-2532. *On a Mutation Selection Model.* Preliminary report.

A selection-mutation model where individuals are distributed over a discrete trait space is studied. It is shown that for the small mutation case an equilibrium exists in which all traits co-exist and the equilibrium is globally attracting and asymptotically stable. (Received September 10, 2010)

1067-92-640 **Natali Hritonenko*** (nahritonenko@pvamu.edu), Department of Mathematics, Prairie View A&M University, Prairie View, TX 77446, **Renan-Ulrich Goetz** (nahritonenko@pvamu.edu), Department of Economics, University of Girona, Girona, Spain, and **Deonica Paxton** (nahritonenko@pvamu.edu), Department of Mathematics, Prairie View A&M University, Prairie View, TX 77446. *Sustainable Forest Management, Logging Size, and Carbon Sequestration Under Climate Changes.*

A mathematical model depicts the forest management problem that considers benefits from timber production and carbon sequestration facing climate changes. It is presented as a boundary value problem for nonlinear partial differential equations with integral terms. The model takes into account the size structure of trees, intra-species competition, and density effects and considers changes of parameters as consequence of climate change. Delay differential equations describe delayed processes of carbon sequestration. The dynamics of climate change is taken from known global scenarios and incorporated in the model. The model is tested on real data on forest in Spain. The objective function includes the revenue from timber production, operational expenses, and profit from carbon sequestration. The dual system is derived and a maximum principle is obtained. The provided qualitative analysis assists in understanding of how environmental changes impact biological processes of forest and carbon sequestration, shows the dynamics of change of carbon price and the optimal logging time under various climate change scenarios, and suggests how management of carbon sequestration and timber production can be adapted to climate changes. (Received September 12, 2010)

1067-92-654 **J. M. Cushing*** (cushing@math.arizona.edu), Department of Mathematics, 617 N Santa Rita, University of Arizona, Tucson, AZ 85719, and **A. S. Ackleh**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504. *The Net Reproductive Number R_0 for Periodic Matrix Models of Structured Population Growth.*

We define the net reproductive number R_0 for a linear periodic matrix model by providing an appropriate additive decomposition of the projection matrix of the composite map. This definition leads to a straightforward generalization of the standard definition of R_0 for autonomous matrix equations and its biological interpretation. It is shown that the Cushing-Yicang theorem holds, i.e., that R_0 and r (the inherent growth rate of the periodic map) lie on the same side of 1. We compare our definition with another definition given recently in the literature and show that they are not in general equal. This fact can lead to not only to different estimates for a population's net reproductive number R_0, but to different (even opposite) conclusions from a sensitivity analysis performed on R_0. (Received September 13, 2010)

1067-92-655 **Alethea Barbaro*** (alethea@math.ucla.edu). *Limiting PDEs for Social Dynamics.* Preliminary report.

Interacting particle systems have been used to model a wide range of complex systems. Recently, these models have been shown to be effective at modeling macroscopic dynamics of large numbers of socially interacting biological organisms such as locust swarms, fish schools, and human crowds. Since simulations of interacting particle models are computationally expensive and also are difficult to analyze, there is much to be gained from kinetic and hydrodynamic descriptions of these systems. Here, we focus on one class of these models which has been widely used to simulate fish schools. We describe the formal derivation of a corresponding hydrodynamic model and discuss the correspondence between the hydrodynamic model and the original particle system. (Received September 13, 2010)

1067-92-694 **Libin Rong*** (rong2@oakland.edu), Dept of Math and Stat, Rochester, MI 48309, **Harel Dahari**, Chicago, IL 60612, **Ruy Ribeiro**, Los Alamos, NM 87545, and **Alan Perelson**, Los Alamos, NM 87545. *Hepatitis C virus drug resistance and modeling.*

About 170 million people worldwide are infected with hepatitis C virus (HCV). The current standard therapy leads to sustained viral elimination in only approximately 50% of the treated patients. Telaprevir, an HCV protease inhibitor, has substantial antiviral activity in patients with chronic HCV infection. However, in clinical trials, drug-resistant variants emerge at frequencies of 5 to 20% of the total virus population as early as the second day after the beginning of treatment. Here, using probabilistic and viral dynamic models, we show that such rapid emergence of drug resistance is expected. We calculate that all possible single- and double-mutant viruses preexist before treatment and that one additional mutation is expected to arise during therapy. Examining data from a clinical trial of telaprevir therapy for HCV infection in detail, we show that our model fits the observed dynamics of both drug-sensitive and drug-resistant viruses and argue that therapy with only direct antivirals will require drug combinations that have a genetic barrier of three to four mutations. (Received September 13, 2010)

1067-92-709 **Sebastian Schreiber*** (sschreiber@ucdavis.edu), Department of Evolution and Ecology, One Shields Avenue, University of California, Davis, CA 95616. *Persistence of interacting populations in fluctuating environments.*

Understanding under what conditions interacting populations, whether they be plants, animals, or viral particles, persist is a question of theoretical and practical importance in population biology. Both biotic interactions and environmental fluctuations are key factors that can facilitate or disrupt persistence. To better understand this interplay between these deterministic and stochastic forces, I will present a mathematical theory extending the theory of persistence for deterministic systems to stochastic difference and differential equations. Using this theory, I will illustrate how (i) an arbitrary number of species competing for a single limiting resource can coexist and (ii) environmental noise enhances or inhibits coexistence in communities with rock-paper-scissor dynamics. Much of this work was done in collaboration with Michael Benaïm and Kolawolé A. S. Atchadé (Université de Neuchâtel). (Received September 13, 2010)

1067-92-710 **Abdul-Aziz Yakubu*** (ayakubu@howard.edu), Department Of Mathematics, Howard University, Washington, DC 20059, and **Najat Ziyadi**, Morgan State University, Department of Mathematics, Baltimore, MD 21251. *Disease Dynamics and Allee effect in Discrete-time Population Models.* Preliminary report.

In human disease epidemics models, the timescale of the disease is short and host demography is often ignored. In this talk, we introduce a discrete-time model framework for studying fatal disease dynamics on a timescale that is not negligible in comparison with life expectancy. (Received September 13, 2010)

1067-92-714 **John Rinzel*** (rinzel@cns.nyu.edu), 251 Mercer St, Courant Institute, NYU, New York, NY 10012. *ON-OFF Episodic Activity: Noisy Oscillator or Noise-Driven Attractor Dynamics.*

Alternation between different states is found at various levels in the nervous system from the single cell level (bursting) to perception (e.g., binocular rivalry). Switching can be very abrupt, suggesting an underlying bi- or multi-stability, and random, evidencing an influence of "noise". Typically, in mechanistic models a slow negative feedback ("adaptation") is postulated as a mechanism for terminating an "ON" state. If the feedback is adequately strong switching is automatic and the system operates as a noisy relaxation oscillation. Alternatively, if feedback is not so strong, the system is functionally bistable and noise is essential to trigger the switches. We will describe some dynamical features of such haphazard episodic activity. (Received September 13, 2010)

1067-92-720 **Boris S Gutkin***, 29 rue d'Ulm, 75005 Paris, France. *Probing intrinsic bistability in neurons with noise: a case of inverse stochastic resonance.* Preliminary report.

We report results for single neurons with type II dynamics (subcritical Andronov-Hopf bifurcation present), specifically noise-induced changes in the repetitive firing of Hodgkin-Huxley model neurons. When such models are stimulated with a constant additive current, there is a critical input current density at which sustained periodic firing occurs. For input near this critical value, we find that the firing rate is greatly reduced by noise, even of quite a small amplitude. We also find that the firing rate undergoes a minimum as the noise increases, a phenomenon which is opposite in character to stochastic resonance and hence can be named "inverse stochastic resonance". We discuss the geometric and dynamical conditions for this phenomenon to occur, including the bistability between the stable rest point and sustained firing. We then show that such inverse stochastic resonance occurs in cerebellar Purkinje neurons. This suggests that Purkinje neurons are indeed bistable and that this bistability is an intrinsic membrane property, allowing rapid switching between active and quiescent states. (Received September 14, 2010)

1067-92-735 **Miranda Ijang Teboh-Ewungkem*** (tebohewm@lafayette.edu), Department of Mathematics, 225A Pardee Hall, Lafayette College, Easton, PA 18042, and **Gideon Akumah Ngwa** and **Calistus Ngonghala**. *A mathematical model to highlight the importance of vector demography in malaria dynamics and control.*

A new SIS model has been developed and is used to study and analyze the transmission and dynamics of malaria. The model which takes into consideration the demography of the vector that transmits the parasite that causes malaria is different from the standard SIS model in that oscillatory dynamics is naturally achieved as opposed to being forced via a forcing function. The model will be compared with the standard Ross–Macdonald SIS model to highlight its novelty. (Received September 14, 2010)

1067-92-748 **Dawn Alisha Lott*** (dlott@desu.edu), 1200 N. DuPont Highway, Dover, DE 19901, and **Charles J Prestigiacomo**, **Hans R Chaudhry** and **Michael Siegel**. *Computational fluid dynamic simulation to assess flow characteristics of an in vitro aneurysm model.*

This study develops a virtual two-dimensional flow model replicating an in vitro aneurysm model and analyzes how changes in morphology modify flow characteristics. Using finite volume analysis, a two-dimensional saccular aneurysm model was created with a configuration matching a published, experimental, in vitro model. Qualitative comparisons were made determining whether a two-dimensional fluid dynamic model can replicate the results of an in vitro model. Quantitative changes in flow patterns, wall shear stress, dynamic pressure and maximum velocities were assessed by modifying the shape of the neck and proximal dome without modifying the overall size of the aneurysm. A two-dimensional computational fluid dynamic model reproducing the shape of a published aneurysm demonstrated excellent qualitative fidelity to an in vitro flow model. Additional information regarding dynamic pressure, shear stress and velocity along the aneurysm neck and within the aneurysm dome were determined. Although all dimensions were kept constant, slight modifications of the neck and proximal dome resulted in quantitative changes in studied parameters, such as wall shear stress and dynamic pressure. (Received September 14, 2010)

1067-92-752 **Zhilan Feng**, **Ronsong Liu**, **Zhipeng Qiu** and **Joaquin Rivera*** (jriveracruz@colgate.edu), 13 Oak Drive, Hamilton, NY 13346, and **Abdul-Aziz Yakubu**. *Coexistence of competitors in deterministic and stochastic patchy environments.*

The spatial component of ecological interactions plays an important role in shaping ecological communities. A crucial ecological question is how does habitat disturbance and fragmentation affect species persistence and diversity? In this paper, we develop a deterministic metapopulation model that takes into account a time-dependent patchy environment, thus our model and analysis takes into account environmental changes. We investigate the effects that spatial variations have on persistence and coexistence of two competing species. In particular, we study the local behavior of the model, and we provide a rigorous proof for the global analysis of our model. Also, we compare the results of the deterministic model with simulations of a stochastic version of the model. (Received September 14, 2010)

1067-92-758 **Shandelle M Henson*** (henson@andrews.edu), Dept of Mathematics, Andrews University, Berrien Springs, MI 49104. *A Darwinian dynamics model for the evolution of "comfort behavior" in seabirds.* Preliminary report.

Heritable behaviors that serve important physiological functions can be co-opted to serve psychological purposes. For example, in humans the behavior of eating can be used as a "comfort behavior". Preening is an important behavior in birds that occupies up to 27% of waking time on their territories. The most obvious function of this behavior is feather maintenance, which is crucial for flight and thermoregulation. Studies suggest that preening also can serve as a "comfort behavior" that soothes birds after periods of disturbance by predators. We use a Darwinian dynamics model to suggest mechanisms by which a behavior with physiological function can evolve into a comfort behavior. (Received September 14, 2010)

1067-92-761 **David Cai*** (cai@cims.nyu.edu), Courant Institute, New York University, 251 Mercer Street, New York, NY 10012. *Stochastic Operating Point for the Dynamics of the Primary Visual Cortex.*

We discuss our large-scale (1 million neurons) computational modeling of the primary visual cortex (V1). In particular, we describe an intermittent depressed state as a possible stochastic operating point of the V1 dynamics. Under this operating point, we further discuss possible network mechanisms underlying spatiotemporal dynamics associated with spontaneous on-going activity of the V1 and the line-motion illusion — which is the illusory motion sensation from a static cue of a flashed stationary square quickly followed by a stationary bar. Furthermore, we use a new analysis of coarse-grained stochastic event-chains to demonstrate the fine discriminability of orientation of V1. (Received September 14, 2010)

1067-92-769 **Bassidy Dembele*** (dem_77@hotmail.com), 215 Penny ln apt 3, Ruston, LA 71270, and **Abdul-Aziz Yakubu** (ayakubu@howard.edu), 204 Academic Support Building B, Washington DC, DC 20059. *Optimal Use Of Mosquito treated nets and Insecticide In Controlling Malaria Disease.*

In this work, we use mathematical models to study the impact of mosquito bed nets and insecticide on the incidence of malaria disease. As a case study, we use our mathematical model to fit clinical data obtained from Missira, a malaria endemic region of Mali. Using the clinical data, we determine the optimal number of people that need to be protected and the optimal number of mosquitoes that need to be killed in order to control the malaria disease in the region. (Received September 14, 2010)

1067-92-771 **Carson C Chow*** (carsonc@niddk.nih.gov), NIH/NIDDK/LBM, Bldg 12A, Rm 4007, Bethesda, MD 20892, and **Michael A Buice** (buicem@niddk.nih.gov), NIH/NIDDK/LBM, Bldg 12A, Room 4007, Bethesda, MD 20892. *Finite-size effects in globally coupled neural networks.*

We investigate the population statistics and dynamics of a recurrent network of globally coupled quadratic integrate and fire neurons and present a formalism for computing the statistics in a finite size expansion. The small parameter for the expansion is the inverse number of neurons. The potentials in the network are reduced to phase oscillators. The evolution of the population density of these coupled oscillators is then inferred from the network dynamics, which is in turn used to construct an expression for the population statistics of the network in terms of a probability distribution of population densities. A steepest descent evaluation of the moments of this probability distribution yields the expansion. We derive both the mean field equation (the lowest order approximation) as well as coupled equations for the mean and correlation function for this network, and demonstrate how higher moments and corrections can be calculated. (Received September 14, 2010)

1067-92-774 **Michael A Buice*** (buicem@niddk.nih.gov), NIH/NIDDK/LBM, Bldg 12A, Rm 4007, Bethesda, MD 20892, and **Carson C Chow** (carsonc@niddk.nih.gov), NIH/NIDDK/LBM, Bldg 12A, Room 4007, Bethesda, MD 20892. *Heterogeneity and Stability in globally coupled neural networks.*

We investigate the effects of heterogeneity on the population statistics and the stability of neural networks. Our model system is a set of quadratic integrate-and-fire neurons coupled through a global activity variable. We demonstrate the conditions for stability of this system and show how the level of heterogeneity effects these conditions. We discuss the impact of heterogeneity on the possibility of various coding schemes in the network, for example whether the neurons respect a phase-coding versus a rate-coding mechanism. In addition, we demonstrate how to derive an effective activity equation (an expression for the dynamics of the global coupling variable which accounts for the phase relationships of the neurons) and discuss its relation to coding. (Received September 14, 2010)

1067-92-802 **Yicong Yong*** (yongyic@ufl.edu) and **Xingzhou Yang** (xyang@math.msstate.edu), 458 Allen Hall, Department of Mathematics and Statistics, Mississippi State University, Mississippi State, MS 39762. *Modeling Particle Dynamics around Choanoflagellates by the Regularized Stokeslets.* Preliminary report.

Choanoflagellates are unicellular microorganisms with a single flagellum surrounded by microvilli, slender fingerlike, very thin projections. Recent study shows that choanoflagellates are most relative to animals and they may reveal the origin of life. In this complex biological system, the helical beat of the flagellum is responsible for the motility of choanoflagellates. The microvilli can filter and take in the food particles or nutrient substances. We present a computational model to understand the particle dynamics around the choanoflagellates. The nutrient substances suspended within the fluid are modeled as neutral buoyant particles. The flagellum and the microvilli are treated as elastic structures in the model. In our computer simulations, we show the flow patterns by visualizing how the flagellum, microvilli, suspended particles interact with the surrounding fluid. Since the Reynolds number is very low, the fluid flow is modeled by Stokes equations. We use the regularized Stokeslets method, a grid free method, to solve the governing equations. The Runge-Kutta method is employed to solve the related ODE system. Numerical simulations will be presented. (Received September 14, 2010)

1067-92-824 **Kresimir Josic*** (josic@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204-3008, **Robert Rosenbaum** (josic@math.uh.edu), University of Houston, Department of Mathematics, Houston, TX 77204-3008, and **James Trousdale**, Department of Mathematics, University of Houston, Houston, TX 77204-3008. *Mechanisms that modulate the transfer of spiking correlations.*

Correlations between the spiking activity of neurons impact the dynamics and information carried by neuronal networks. A fundamental problem in the study of correlations is that of correlation transfer: Given that neurons receive correlated inputs, what is the correlation between their outputs? Many recent studies have addressed this question by approximating the inputs by Gaussian noise. Such models are obtained in the limit of a large number of inputs with infinitesimal postsynaptic response amplitudes.

We address the problem of correlation transfer by modeling input spike trains as point processes and where each input spike elicits a finite postsynaptic response. Ideas from renewal theory provide intuitive insights into the mechanisms behind correlation transfer in drift and fluctuation dominated regimes. This approach also allows us to model synaptic noise and recurrent coupling in a natural way, and treat excitatory and inhibitory inputs separately. We find that the effects of synaptic noise and excitatory"to"inhibitory correlations, which are often ignored when inputs are modeled as Gaussian noise, can significantly reduce output correlations. (Received September 15, 2010)

1067-92-874 **Joel C Miller*** (joel.c.miller.research@gmail.com), 677 Huntington Ave, Boston, MA 02115, and **Erik Volz**. *Network epidemics with just one equation.*

The structure of social interactions along which disease spreads can be represented using a network. When we investigate disease spread in networks we find that many mass action assumptions fail. Individuals with many contacts tend to become infected earlier, and in turn infect more individuals, leading to faster initial growth. However, the remaining population has fewer contacts than average, and so the growth rate decreases more rapidly and the epidemic dies out sooner than mass action predicts.

Unfortunately models tend to require (arbitrarily) many equations to correct this. Recent work by Volz (JMB 2008) found a low-dimensional system that exactly captures the dynamics. Work by Miller (JMB 2010) simplified this derivation and also simplified the equations.

Our more recent unpublished work simplifies the derivation further, and allows easy generalization to a wide range of diseases and population structures, including populations whose contacts change in time. The key simplification comes from focusing our attention on the fraction of edges connecting to susceptible, infected, or recovered individuals rather than the fraction of the population with each status. We show how to derive these systems and compare the resulting predictions with simulation. (Received September 15, 2010)

1067-92-925 **De Witt Sumners*** (sumners@math.fsu.edu), Department of Mathematics, Florida State University, Tallahassee, FL 32306. *DNA Knotting in Bacteriophage Capsids.*

Recent experiments showed that the linear double-stranded DNA in bacteriophage capsids is both highly knotted and neatly structured. What is the physical basis of this organization? Here we show evidence from stochastic simulation techniques that suggests that a key element is the tendency of contacting DNA strands to order, as in cholesteric liquid crystals. This interaction favors their preferential juxtaposition at a small twist angle, thus promoting an approximately nematic (and apolar) local order. The ordering effect dramatically impacts the geometry and topology of DNA inside phages. Accounting for this local potential allows us to reproduce the main experimental data on DNA organization in phages, including the cryo-EM observations and detailed features of the spectrum of DNA knots formed inside viral capsids. The DNA knots we observe are strongly delocalized and, intriguingly, this is shown not to interfere with genome ejection out of the phage.

D. Marenduzzo, E. Orlandini, A. Stasiak, D.W. Sumners, L. Tubiana, C. Micheletti. DNA-DNA Interactions in Bacteriophage Capsids are Responsible for the Observed DNA Knotting, Proc. National Academy of Sciences USA 106 (2009), 22269-22274. (Received September 16, 2010)

1067-92-930 **Mariel Vazquez*** (mariel@math.sfsu.edu), Mathematics Department, San Francisco State University, 1600 holloway Avenue, San Francisco, CA 94116. *The XerCD-FtsK system unlinks replication catenanes in a stepwise manner.*

Replication of circular chromosomes requires unwinding of the DNA and results in the formation of DNA links. In Escherichia coli, error-free unlinking is required to ensure proper segregation at cell division, thus highlighting the importance to characterize the topological mechanism of DNA unlinking. The site-specific recombination system XerCD mediates sister chromosome unlinking in TopoIV deficient cells. This reaction is activated by FtsK, a powerful DNA translocase, which coordinates the last stages of chromosome segregation.

We here study the topological mechanism of DNA unlinking by the XerCD-FtsK system using knot theory and computer simulations. We use the tangle method to find possible topological pathways of DNA unknotting and unlinking by site-specific recombination on small substrates. When assuming that the enzymes systematically reduce the topological complexity of the substrates, we provide rigorous proof that there is only one possible unlinking pathway. For example the XerCD-FtsK system unlinks 6-crossing catenanes in a stepwise manner, converting the 6-cat into a 5-knot, into a 4-cat, into a 3-knot etc... until reaching the unlinked state. This is joint work with Koya Shimokawa, Kai Ishihara, Ian Grainge, David J.Sherratt. (Received September 16, 2010)

1067-92-936 **James M Hyman*** (mhyman@tulane.edu), Tulane University, Dept. of Mathematics, New Orleans, LA 70118, **Nakul Chitnis** (Nakul.Chitnis@unibas.ch), Swiss Tropical Institute, Department of Public Health and Epidemiology, Basel, Switzerland, Switzerland, and **Carrie Manore** (manorec@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97330. *Modeling Vertical Transmission in Mosquito-Transmitted Diseases.*

We will describe how mathematical modeling can be used to better understand the effectiveness of intervention strategies for stopping emerging and re-emerging vector-borne infectious diseases, including: malaria, dengue fever, and West Nile virus, and Rift Valley Fever (RVF). We will present and analyze a new model for mosquito-transmitted disease that includes vertical transmission mechanisms from an infected mosquito mother to infected offspring. We analyze the importance of vertical transmission in predicting the spread of RVF and discuss how modeling can reduce the uncertainty of the estimates of disease prevalence, and thus facilitate estimating the cost/benefit analysis of projected interventions. (Received September 16, 2010)

1067-92-1005 **Rongsong Liu*** (rliu1@uwyo.edu), Department of Mathematics, Laramie, WY 82071, **Carlos Martinez del Rio** (CmDelRio@uwyo.edu), Department of Zoology and Physiology, Laramie, 82071, and **Jianhong Wu**, Department of Mathematics and Statistics, Toronto, Ontario M3I1P3, Canada. *Spatiotemporal variation of mistletoes: a dynamic modeling approach.*

Mistletoes are common aerial stem-parasites and their seeds are dispersed by fruit-eating birds. In the mutually beneficial relationships between mistletoes and bird species that disperse mistletoes seeds, the preference of birds for infected trees influences the spread of mistletoes and the spatiotemporal pattern formation of mistletoes. We formulate a deterministic model to describe the dynamics of mistletoes in an isolated patch containing arbitrary number of trees. We establish concrete criterions, expressed in terms of the model parameters, for mistletoes establishing in this area. We conduct numerical simulations based on a field study to reinforce and expand our results. (Received September 17, 2010)

1067-92-1021 **Jeremy J. Thibodeaux*** (thibodea@loyno.edu), Loyola University New Orleans, Department of Mathematical Sciences, Campus Box 35, New Orleans, LA 70118, and **Timothy Schlittenhardt**. *An Optimal Treatment Strategy for Malaria Infection.* Preliminary report.

A size-structured model of erythropoiesis subject to malaria infection will be presented. The model consists of a system of two nonlinear hyberbolic partial differential equations and three ordinary differential equations. Through sensitivity analysis, it has been previously found that the model is particularly sensitive to the number of parasites released per bursting infected erythrocyte (red blood cell). By using techniques of optimization, we will show that the model predicts periodic treatments that focus on the aforementioned parameter as an optimal strategy. (Received September 17, 2010)

1067-92-1063 **Anuj Mubayi*** (anujmubayi@yahoo.com), 2201 Milton Road, Apt 306, University Heights, OH 44118. *Transmission Dynamics of Kala-azar in Bihar and Impact on Public Health Policies.* Preliminary report.

A mathematical model is used to study the transmission dynamics and spread of Kala-Azar (or Visceral Leishmaniasis or VL) in one of the world's major foci of the disease, the Indian state of Bihar. This research has been motivated by reported (clinical) incidence and mortality data that exclude cases treated in private health facilities who are not required to report cases by law. VL asymptomatic and post-kala-azar dermal leishmaniasis cases also acts as reservoirs of parasites. At present, the state health care funds are distributed based only on the reported clinical data. This study identifies high-risk districts based on adjusted clinical and asymptomatic incidence rates. It also explores the association between underreporting levels and some socioeconomic variables. Our results suggest that clinical underreporting in some districts of Bihar could be as high as 90%. The research findings may facilitate more effective allocation of public health funds for controlling Kala-azar in Bihar. (Received September 17, 2010)

1067-92-1105 **Anna Mummert*** (mummerta@marshall.edu), Marshall University, Mathematics Department, One John Marshall Drive, Huntington, WV 25755, and **Thembinkosi Mkhatshwa**. *Get the News Out Loudly and Quickly: Modeling the Influence of the Media on Limiting Infectious Disease Outbreaks.* Preliminary report.

During outbreaks of serious infectious diseases many individuals closely follow media reports of the outbreak and take steps, including self-isolation, to protect themselves from infection and possibly death. Self-isolation can take many forms including restricting local and long-distance travel, using face masks, and choosing to receive a vaccine.

In this talk, I will use mathematical modeling to show that public health agencies working together with the media can significantly decrease the severity of an outbreak by providing timely and accurate accounts of the numbers of new infections and deaths. This model also shows that although providing such information beginning as early as possible is best, even starting to provide it well into the course of an outbreak can significantly reduce the severity of the outbreak. I will illustrate these results with a simulated outbreak of Ebola Hemorrhagic Fever in Huntington, WV (population 50,000). (Received September 18, 2010)

1067-92-1136 **Abigail Fisher***, Department of Mathematics and Statistics, Smith College, Northampton, MA 01063, and **Elizabeth Cowdery**, **Michelle Winerip**, **Allison Reed-Harris** and **Jayna Resman**. *The Geometry and Dynamics of an Ecological Arms Race.*

This project examines the geometry and dynamics of a predator-prey arms race by comparing growth modes, environmentally induced responses, and foraging effectiveness of two introduced crab species and defense effectiveness of a snail specie along the New England coast. One component of the research concentrates on the dynamical aspects of the predator-prey and competitions systems. The other aspect develops geometric models for the snail shape and explores the influence of shell thickness on overall morphogenesis. The geometric part of the research feeds in the dynamical one by determining the relevant morphogenetic parameters that may influence the population dynamics. (Received September 19, 2010)

1067-92-1137 **Suzanne Lenhart*** (lenhart@math.utk.edu), U of Tennessee, Math Dept, Knoxville, TN 37996. *Modeling the Owned Cat Population in Knox County, Tennessee.* Preliminary report.

Working with data from Young Williams Animal Center in Knoxville, Tennessee, to consider an approach to manage excess numbers of unwanted cats, we constructed a model of the owned female cat population in our county. Considering the age structure and breeding patterns, we constructed a system of difference equations. This model investigates the effect of spaying females at various ages and at different levels on the population growth. This project is in collaboration with Evan Lancaster, John New, Janelle Scott, John Ojogbo, Steven Rekannt, and Heidi Weimer. (Received September 19, 2010)

1067-92-1140 **Suzanne Lenhart*** (lenhart@math.utk.edu), U of Tennessee, Math Dept, Knoxville, TN 37996, and **Sarah Duncan**, University of Alabama, Department of Biological Sciences, Tuscaloosa, AL 35487. *Outreach Activities in Mathematical Biology.*

We discuss two activities for middle or high school students involving ideas at the interface of mathematics and biology. The activities were developed in cooperation with the National Institute for Mathematical and Biological Synthesis. The first activity is about calculating Simpson's index for biodiversity of species.The second activity is a very simple epidemic model with discrete time. (Received September 19, 2010)

1067-92-1148 **Muche A Tilahun*** (tmuche@mail.usf.edu), Mathematics Dept , Art and Science, University of South Florida,4202, E. Fowler Avenue, Tampa, FL 33620-5700. *Chord graphs associated with DNA recombination in Ciliates.* Preliminary report.

Tilahun A Muche, University of South Florida

Graphs with 4 valent rigid vertices and two end points, called assembly graphs, represent DNA recombination that appear in certain species of ciliates. A recombination is modeled by smoothing of the 4-valent vertices which is guided by certain types of paths in the graph, called polygonal paths. We represent the simple assembly graph by a double occurrence word $w = a_1a_2\dots a_{2n}$ over the finite alphabet $\sum$ with $|\sum| \geq n$ and we define a prime assembly word if it contains no sub-assembly word. A transversal path $\gamma = (a_1, e_1, a_2, e_2, - - -, e_n, a_n)$ of a simple assembly graph Γ_w corresponds to consecutive sequences of arcs $e_i = (a_i, a_{i+1})$ for a chord graph and a polygonal path of a assembly graph corresponds to arc-chord-arc sequences of the chord graph. We find assembly number for certain simple assembly graphs that correspond to prime assembly words using arc-chord-arc sequences of the chord graph. (Received September 22, 2010)

1067-92-1163 **Karen M. Bliss*** (kmbliss@ncsu.edu), Department of Mathematics, North Carolina State University, Campus Box 8205, Raleigh, NC 27606. *Model and Simulation of Red Blood Cell Dynamics in Patients with Chronic Kidney Disease.* Preliminary report.

Kidneys are the main site of production of the hormone erythropoietin (EPO) that is the major regulator of erythropoiesis, or red blood cell production. EPO level is normally controlled by a negative feedback mechanism in the kidneys, but patients with chronic kidney disease (CKD) do not produce sufficient levels of EPO to maintain blood hemoglobin concentration.

In order to prevent anemia, patients typically receive recombinant human EPO (rHuEPO) intravenously to stimulate red blood cell production. Iron is required to produce hemoglobin, and iron deficiency can be an issue among patients receiving rHuEPO therapy, so intravenous iron supplementation is common among patients undergoing rHuEPO therapy.

An age-structured model is developed for red blood cell dynamics in patients with CKD. Both rHuEPO therapy and iron therapy are taken into consideration, as is the overall inflammation level in the body. Simulations are performed under various conditions and treatment protocols.

This is joint work with H.T. Banks and H.T. Tran of the Center for Research in Scientific Computation at North Carolina State University, along with Peter Kotanko of Renal Research Institute in New York. (Received September 19, 2010)

1067-92-1183 **Georgiy P Karev*** (karev@ncbi.nlm.nih.gov), 3014 Homewood Pkwy, Kensington, MD 20895. *Mathematical theory of selection and the Principle of minimum discrimination information.*

Dynamics of many complex systems can be described by replicator equations (RE). Here we present an effective method for solving a wide class of RE based on reduction theorems for models of inhomogeneous communities. The solutions of the RE minimize the discrimination information of the initial and current distributions at each point of the system trajectory, not only at the equilibrium, under time-dependent constraints. Applications to inhomogeneous versions of some conceptual models of mathematical biology (logistic and Ricker models of populations and Volterra' models of communities) are given. (Received September 19, 2010)

1067-92-1208 **Byong Y Kwon*** (bkwon1@masonlive.gmu.edu). *Computational docking of molecular wires to the reaction center of Rhodobacter sphaeroides.* Preliminary report.

Given the worldwide interest in renewable energy, scientists have been exploring the possibility of using bacterial photosynthetic reaction centers to build a new generation of highly efficient photovoltaic devices. To build such devices, molecular wires (MWs) that serve as good conductors to transport electrons from and to the reaction centers are needed. The MWs must dock at specific binding sites within the reaction centers. We explore computational models of docking MWs to the reaction centers. Such models can help in proposing suitable MWs for photovoltaic devices. For our modeling, we use the reaction center of Rhodobacter sphaeroides, a purple photosynthetic bacteria. (Received September 20, 2010)

1067-92-1230 **Rachael L Miller Neilan*** (rmill48@lsu.edu), 2139 Energy, Coast, and Environment Building, Louisiana State University, Baton Rouge, LA 70803, and **Kenneth Rose**, **Sean Creekmore**, **Kevin Craig** and **Peter Thomas**. *Quantifying the effects of low dissolved oxygen on the growth, reproduction, and survival of fish.*

Low dissolved oxygen (DO) is a widespread and increasingly prevalent stressor in estuaries and coastal seas. Exposure to low DO can inhibit fish growth and reproduction and may result in death. We present an exposure-effects model that quantifies the reduction in an individual's vital rates (growth, reproduction, survival) given its DO exposure history. We estimate model parameters using published, constant exposure lab experiments and then use the model on an hourly time-step to predict the effects of fluctuating DO exposures. We illustrate the model's ability to replicate the growth, reproduction, and survival of a variety of species exposed to intermittent low DO in lab experiments. Finally, we present some preliminary results from the exposure-effects model embedded within a larger individual-based model designed to simulate the effects of hypoxia (DO $\leq$ 2.0 mg/l) on the population dynamics of Atlantic croaker, a common demersal fish species, in the northern Gulf of Mexico. (Received September 22, 2010)

1067-92-1236 **Hassan M Fathallah-Shaykh*** (hfathall@uab.edu), FOT 1020, 1530 3rd Avenue South, Birmingham, AL 35294-3410. *Dynamics Of The Drosophila Circadian Clock: Theoretical Anti-Jitter Network And Controlled Chaos.*

Electronic clocks exhibit undesirable jitter or time variations in periodic signals. The circadian clocks of humans, some animals, and plants consist of oscillating molecular networks with peak-to-peak time of approximately 24 hours. Clockwork orange (CWO) is a transcriptional repressor of Drosophila direct target genes. Theory and data from a model of the Drosophila circadian clock support the idea that CWO controls anti-jitter negative circuits that stabilize peak-to-peak time in light-dark cycles (LD). The orbit is confined to chaotic attractors in both LD and dark cycles and is almost periodic in LD; furthermore, CWO diminishes the Euclidean dimension of the chaotic attractor in LD. Light resets the clock each day by restricting each molecular peak to the proximity of a prescribed time. The theoretical results suggest that chaos plays a central role in the dynamics of the Drosophila circadian clock and that a single molecule, CWO, may sense jitter and repress it by its negative loops. (Received September 20, 2010)

1067-92-1268 **Kaibin Fu*** (kafu@pvamu.edu), Department of Mathematics, Prairie View A&M University, Prairie View, TX 77446. *Undergraduate research examples on Mathematical Modeling in Environmental Economics.*

First, we will give a general description on the new UBM program at Prairie View A&M University, a member of HBCU. This new 5-year program is funded by NSF and targets on undergraduate research experiences in biological and mathematical sciences. Then we will give some undergraduate research examples on mathematical modeling, particularly in environmental economics. (Received September 20, 2010)

1067-92-1297 **Linda J. S. Allen*** (linda.j.allen@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, **Yuan Yuan**, University of Texas MD Anderson Cancer Center, Houston, TX 77230-1402, and **Sukhitha Vidurupola**, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *Stochastic Viral Kinetics.*

Ito stochastic differential equation (SDE) models are derived for viral kinetics. Estimates for mean and variance of the distribution over time are obtained from the moment differential equations. In addition, the SDEs and theory from branching processes are used to make predictions about the probability of a successful viral transmission. (Received September 20, 2010)

1067-92-1369 **Pei Zhang*** (pxz2351@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, and **Azmy S. Ackleh** (ackleh@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010. *A Discrete Stage-Structured Two Species Competition Model.*

We develop a discrete stage-structured model that describes the dynamics of two competing ecologically similar species. Motivated by plant populations such as irises, each species is assumed to reproduce both sexually and clonally. We first analyze the dynamical behavior of the single species model. We show that when the inherent net reproductive number is smaller than one then the population will go to extinction and if it is larger than one then an interior equilibrium exists and it is globally asymptotically stable. For the two-species competition model, by allowing species to have different competition efficiencies, we show that the model can obtain different dynamics including competitive exclusion, coexistence and bistability, which is similar to the competition outcomes of the classical continuous two-dimensional Lotka-Volterra model. (Received September 20, 2010)

1067-92-1388 **Joanna Pressley*** (j.pressley@vanderbilt.edu), 1326 Stevenson Center, Nashville, TN 37240, and **Erika M. C. D'Agata** and **Glenn F. Webb**. *The effect of co-colonization with community-acquired and hospital-acquired methicillin-resistant Staphylococcus aureus strains on competitive exclusion.*

We investigate the in-hospital transmission dynamics of two methicillin resistant *Staphylococcus aureus* (MRSA) strains: hospital-acquired methicillin resistant (HA-MRSA) and community-acquired methicillin resistant *Staphylococcus aureus* (CA-MRSA). Under the assumption that patients can only be colonized with one strain of MRSA at a time, global results show that competitive exclusion occurs between HA-MRSA and CA-MRSA strains. Because new studies suggest that patients can be concurrently colonized with multiple strains of MRSA, we extend the model to allow patients to be co-colonized with HA-MRSA and CA-MRSA. Using the extended model, we explore the effect of co-colonization on competitive exclusion by determining the invasion reproduction ratios of the boundary equilibria. In contrast to results derived from the assumption that co-colonization does not occur, the extended model rarely exhibits competitive exclusion. When transmission rates are assumed equal and decolonization measures act equally on both strains, competitive exclusion never occurs. Other interesting phenomena are exhibited. For example, solutions can tend toward a co-existence equilibrium, even when the basic reproduction ratio of one of the strains is less than one. (Received September 20, 2010)

1067-92-1426 **Samantha H Erwin** (samantha.erwin@murraystate.edu), 823 Eastland Dr., Villa Hills, KY 41017, and **Aron J Huckaba*** (aron.huckaba@murraystate.edu), 307 Lankford Rd., Paris, TN 38242. *Using matrix analysis to model the spread of an invasive plant, Alternanthera philoxeroides.* Preliminary report.

Alternanthera philoxeroides, more commonly known as alligator weed is an invasive specie indigenous to South America. With its alarming invasion of south east United States water ways, action to control this weed is both important and imperative. Utilizing experimental growth data obtained over the summer of 2010 matrix models can be used to precisely model the growth of alligator weed. These matrices are population projection models which represent the growth rate of alligator weed in its many stages. An on going attempt to use Monte Carlo simulations to predict patterns of future growth using the population projection matrices will be discussed. (Received September 21, 2010)

1067-92-1434 **Shantia Yarahmadian*** (syarahmadian@math.msstate.edu), Department of Mathematics and Statistics, Mississippi State, MS 39762, and **Sidney L. Shaw**. *The effect of sampling rate on the statistics of microtubules.* Preliminary report.

Microtubules are long, proteinaceous filaments that perform structural functions in eukaryotic cells by defining cellular shape and serving as tracks for intracellular motor proteins. Using Dichotomous Markov Noise (DMN) and signal processing techniques, we will study the effect of sampling rate in the measurement of dynamic instability parameters of microtubules. For this study, we will use a generalized PDE model for microtubule dynamics to the case where the rates of elongation as well as the lifetimes of the elongating and shortening phases are a function of GTP-tubulin concentration. (Received September 21, 2010)

1067-92-1436 **Brent Doiron*** (bdoiron@pitt.edu), Department of Mathematics, University of Pittsburgh, 301 Thackeray Hall, Pittsburgh, PA 15206. *Correlation shaping in spiking neurons.*

Correlated activity between neural spike trains is widespread across the brain, well documented in sensory, cognitive, and motor areas. Neural correlations impact the coding performed by a population of neurons, as well as mediate interactions between distinct pools of neurons. More recently, experiments from a variety of brain areas have shown that the correlation between neurons, measured over a broad range of timescales, can be shaped by both stimuli and the cognitive state of a subject. Despite these observations, the underlying mechanisms responsible for shaping correlations are poorly understood. Drawing from techniques in point process theory as well as non-equilibrium statistical mechanics, we present a simple framework that models how the susceptibility for neurons to correlate to external, shared fluctuations is shaped by background modulatory inputs and feedforward inhibition. In a variety of situations we find that increases in short timescale correlation (synchrony) are associated with decreases in long timescale correlation (co-variation in firing rates). Theoretical results will match experimental findings from cortical slices, and in vivo recordings from somatosensory cortex as well as brainstem areas in weakly electric fish. (Received September 21, 2010)

1067-92-1474 **L. R. Ritter*** (lritter@spsu.edu), 1100 S. Marietta Pkwy, Dept. of Mathematics, Marietta, GA 30060, and **A. I Ibragimov** (akif.ibraguimov@ttu.edu) and **J. R. Walton** (jwalton@math.tamu.edu). *General stability analysis of a model of atherogenesis.*

Atherosclerosis is a disease characterized by chronic inflammation and the accumulation of lipids and apoptotic cells in the walls of large muscular arteries. A principal component of the disease process involves the accumulation and oxidation of low density lipoproteins within the arterial wall and its corruptive effect on the immune process. We consider a reaction-diffusion model involving chemo-taxis and perform a general stability analysis accounting for immune cell subspecies interactions and the differing roles of immune cells with respect to the components of an emerging lesion. (Received September 21, 2010)

1067-92-1486 **Franziska Hinkelmann*** (fhinkel@vt.edu), Washington Street, MC 0477, Virginia Tech, Blacksburg, VA 24061, and **Madison Brandon**, **Bonny Guang**, **Rustin McNeill**, **Alan Veliz-Cuba**, **Grigoriy Blekherman** and **Reinhard Laubenbacher**. *Analysis of Discrete Models of Biological Systems Using Computer Algebra.*

Many biological systems are modeled qualitatively with discrete models. Several different modeling types have established communities in the biological sciences, including probabilistic Boolean networks, logical models, bounded petri-nets, and agent-based models. These and other discrete model types can be translated into algebraic models. Using algebraic models as a representation for discrete models allows one to apply theory from algebraic geometry and tools from computational algebra to analyze the dynamic features of such systems. Simulation has become common practice for analyzing discrete models, but most real world biological systems are far too complex to be analyzed by simulation alone. We use various abstract algebra techniques to develop algorithms and software to analyze discrete models for key dynamic features of biological relevance. All algorithms and methods are available trough a web-interface <http://adam.vbi.vt.edu/>. Analysis of Dynamic Algebraic Models (ADAM) has a 'modeler friendly' interface that allows for fast analysis of large models while requiring no understanding of the underlying mathematics or installing software. By providing a user- friendly interface to fast analysis tools, we promote the use of discrete models to model large complex systems. (Received September 21, 2010)

1067-92-1540 **Judith E Canner*** (jcanner@csumb.edu), Department of Mathematics and Statistics, California State University, Monterey Bay, 100 Campus Center, Seaside, CA 93955. *How do we measure the response of species interactions to climate change? The use of models and experiments to study myrmecochory.*

The study of species interactions and climate change relies on an understanding of the transient and long-term responses of species to climate change. In particular, the shifting phenology of species may lead to the decoupling of species interactions with climate change. Though climate manipulation experiments are necessary to observe the cause-and-effect relationships of climate change, the transient dynamics observed in experiments may not reflect the long-term response of a species to climate change. We developed a model of the species interaction, myrmecochory (seed dispersal by ants) to observe the possible responses of the relationship to warming and to assess how we use experiments to predict plant population dynamics under warming. We compared our model under gradual warming conditions to models based on simulated press warming experiments of ant and plant dynamics and found that the predictions of short-term press experiments do not necessarily track the response of myrmecochore populations to gradual warming, especially at high levels of warming. Therefore, we must develop new ways to interpret climate manipulation experiments, in order to create useful models and to predict the persistence of species interactions under climate change. (Received September 21, 2010)

1067-92-1556 **George M. Shakan*** (gshakan@wpi.edu), 2945 Mendon Rd., Cumberland, RI 02864, **Molly S. Eickholt** (m-eickholt@onu.edu), 415 South Simon St., Ada, OH 45810, **Laurel A. Ohm** (ohm@stolaf.edu), 249 S. Segoe Rd., Madison, WI 53705, **Kallyn K. Buschkamp** (kallyn.buschkamp@briarcliff.edu), 3303 Rebecca St., Sioux City, IA 51104, and **Alyssa G. Kent** (agkent@lclark.edu), 9710 SW Corbett Lane, Portland, OR 97219. *Asymptotic Herbiovery and Optimal Resource Allocation: A Cause for Masting.*

Masting in perennial plants is a periodic phenomenon in which plants have years of low reproduction followed by a year of abundant seed-setting, or a mast year. We set out to construct a life history model for perennial plants which incorporates the effects of herbivory, or the predation on plant seeds. Based on prior models and empirical evidence, we predicted that periodic reproduction would optimize plant fitness. In particular, we generalized the Iwasa-Cohen life history model by including the effects of herbivory on plant reproduction. Through our life history model, we found that the optimal reproductive strategy is one which is periodic such that a mast year occurs every J years. (Received September 21, 2010)

1067-92-1659 **Nianpeng Li**, Department of Mathematics, washington, DC 20059, and **Abdul-Aziz Yakubu*** (ayakubu@howard.edu), Mathematics Department, washington, DC 20059. *A Juvenile-Adult Discrete-Time Model Of Exploited Fishery Systems.* Preliminary report.

Previous mathematical modeling of the population dynamics of Georges Bank Atlantic cod fishery employed discrete-time models with no age-structure. These models predict that at recent harvest rates (from 1975-2007), constant and periodic proportion harvesting policies may fail to prevent a collapse of the cod fishery. In this talk, we use an age-structured model to show that at the recent harvesting levels, the cod fishery is sustainable under a constant proportion harvesting policy. (Received September 21, 2010)

1067-92-1683 **Lisa Melanson*** (l-melanson@northwestern.edu), Technology Institute, ESAM Department, 2145 Sheridan Road, Evanston, IL 60208. *Effect of Arterial Geometry on Stresses in Intracranial Aneurysms.* Preliminary report.

Intracranial aneurysms are highly prevalent in the general population and pose life-threatening health risks if left untreated. Wall shear stresses, which are dependent on vessel geometry, can lead to changes in the material properties of the arterial wall allowing aneurysms to grow and potentially rupture. In this study, we examine both elastic and rigid arterial wall models to explore how this remodeling is influenced by geometry and fluid stress. In particular, we investigate the correlation between wall shear stress and aneurysm aspect ratio, outlet and inlet size, and tilt angle of the aneurysm. The two dimensional governing equations are solved numerically using an adaptive finite difference projection algorithm developed at the LBNL Center for Computational Sciences and Engineering coupled with an immersed boundary method. Both idealized arterial geometries as well as geometries extracted from clinical imaging data are considered. (Received September 21, 2010)

1067-92-1724 **Jim M Cushing*** (cushing@math.arizona.edu), Department of Mathematics, University of Arizona, 617 N Santa Rita, Tucson, AZ 85721. *Nonlinear matrix models, evolution, and the dynamic dichotomy of semelparous populations.*

Nonlinear matrix models for the dynamics of structured populations with a semelparous life history possess a dynamic dichotomy when the extinction equilibrium destabilizes (as R_0 increases through 1) and the population becomes persistent. This dichotomy consists, on the one hand, of positive equilibria with overlapping generations and, on the other hand, synchronized periodic oscillations with non-overlapping generations. I will first describe recent results concerning the stability of these two simultaneously bifurcating invariant sets. Secondly, using evolutionary game theory methods, I will place semelparous matrix models into an evolutionary setting and re-consider the dynamic dichotomy. The results will provide conditions under which evolution favors either equilibration with overlapping generations or oscillations with non-overlapping generations. (Received September 21, 2010)

1067-92-1810 **Jue Wang*** (wangj@union.edu), 807 Union St., Schenectady, NY 12308, and **Yongjian Yu**. *Blood Vessel Segmentation in Volumetric Ultrasound.*

Real-time 3D ultrasound imaging has been used to visually guide clinicians inserting central catheters into the blood vessels of premature infants being cared in neonatal intense care unit (NICU) for the delivery of medicine to the hearts. However, it is challenging to visualize the moving blood vessels in the raw images due to the heavy speckle noise and low spatial resolution.

We have developed a 3D blood vessel segmentation method to provide more clinically meaningful views of the catheter in real-time ultrasound. The segmentation proceeds in two steps: a center-line detection, followed by cross-section delineations. A sequential Monte Carlo approach is used to trace the 3D vessel. It is seen as the maximum a posterior (MAP) path of a group of particles driven by both an intrinsic stochastic dynamics and a statistical image data model. The data driven likelihood ratio for vessel extraction is computed using local regional measurements. The cross-sectional contour at each center-line position is then estimated using energy minimization and regularization. It is based on an area-weighted mean difference binary flow with elliptical shape constrains and parameter bounds. The efficacy of the approach is demonstrated using static phantom and in vivo animal datasets. (Received September 21, 2010)

1067-92-1814 **E. T. Camacho** and **L. A. Melara*** (lamelara@ship.edu), Department of Mathematics, 1871 Old Main Drive, Shippensburg, PA 17257, and **M. C. Villalobos** and **S. Wirkus**. *An Optimal Control Mathematical Model for Photoreceptor Interactions.*

Rods and cones play an important role in human vision. While it is natural to have rods and cones die over time, the premature death of cones in the human eye has been linked to the degenerative disease Retinitis Pigmentosa. In this presentation we will focus on a numerical procedure for approximating solutions to a photoreceptor model examining healthy rod and cone interactions. The mathematical model is an optimal control optimization problem where the control variable corresponds to the injection of rod-derived cone viability factor, a protein which helps cones survive. Preliminary numerical results will also be presented. (Received September 21, 2010)

1067-92-1832 **Vrushali A Bokil*** (bokilv@math.oregonstate.edu), 368 Kidder Hall, Department of Mathematics, Oregon State University, Corvallis, OR 97331, and **Carrie Manore**, **Sean M Moore**, **Elizabeth T Borer** and **Parviez R Hosseini**. *A Spatiotemporal Model of Barley and Cereal Yellow Dwarf Virus Transmission Dynamics with Seasonality, Age Structure and Plant Competition.*

In this talk we present a model for transmission of barley and cereal yellow dwarf viruses (B/CYDV) spread by aphid vectors among non-native annual and native perrenial grass species in the western United States. We model transmission of disease within a patch framework that incorporates the movement of aphid vectors between discrete patches. Our spatiotemporal model incorporates age structure in perrenial grasses, competition between the grass species and seasonal variations in population dynamics of the host species. Using this B/CYDV system as a case study we investigate the effects of spatial distributions and relative abundances of different host species on disease dynamics. An analysis of a simplified two-patch model identifies how key parameters influence both the ability of the pathogen to invade a heterogeneous host community and the effect of the pathogen on host coexistence. Numerical simulations over a larger group of patches demonstrate that increasing connectivity between patches tends to increase prevalence at the regional scale. We find that host composition and patch structure can affect not only the ability of the pathogen to invade a system but can either facilitate or hinder invasion by non-native competitor host species. (Received September 22, 2010)

1067-92-1914 **John E. Franke*** (franke@math.ncsu.edu), Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695-8205, and **Matthew A. Morena**. *Predicting Attenuant and Resonant 2-Cycles in Periodically Forced Discrete-Time 2-Species Population Models.* Preliminary report.

Periodic environments are commonly observed in nature and may either enhance or suppress a population. We study the responses of two competing discretely reproducing populations to periodic fluctuations in four parameters. Two of these parameters are related to a nontrivial equilibrium (carrying capacity) and the other two are quite arbitrary and could be related to environmental factors or growth rates. We prove that small, 2-periodic fluctuations in the four parameters support 2-cyclic oscillations of the populations. We then develop signature functions for predicting the responses of the populations to 2-periodic fluctuations in the environment. Each signature function is the sign of a weighted sum of the relative strengths of the oscillations of the perturbed parameters. Periodic environments are favorable for the total biomass and for each species if the corresponding signature function is positive but are deleterious when the corresponding signature function is negative. We compute the signature functions for three classical discrete-time, two species population models, and then determine regions in parameter space which are either favorable or detrimental to the populations. The three 2-D models studied are Logistic, Ricker, and Beverton-Holt type models. (Received September 22, 2010)

1067-92-1933 **Justin S Blackwell*** (jblackwell@uta.edu), Department of Mathematics, University of Texas at Arlington, P.O. Box 19408, Arlington, TX 76019. *A Modeling Study of Synaptic Neurotransmission and Independent Signaling of NMDA Receptors.* Preliminary report.

In a synapse, spontaneous and action-potential-driven neurotransmitter releases were generally assumed to activate the same set of postsynaptic receptors. New experimental and numerical results now support the premise that these two different release events activate distinct sets of NMDA receptors and independently signal postsynaptic receptors in postsynaptic terminals larger than $\sim 0.2\,\mu\text{m}^2$. A computational model is constructed to simulate the diffusion of the neurotransmitter, glutamate, within the synaptic cleft as well as the receptor kinetics to determine opening probabilities that give rise to postsynaptic currents. We consider various factors within the synapse that can accommodate independent signaling in smaller synapses, such as variations in the spatial domain, release rate, and diffusion coefficient of the neurotransmitter. The modeling study collaborates with experimental results and gives a plausible explanation for synaptic noise from spontaneous release to be independent from action-potential-driven synaptic signals. (Received September 22, 2010)

1067-92-1970 **Qihua Huang*** (qxh6207@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, **Azmy S. Ackleh**, Lafayette, LA 70504-1010, and **Keng Deng**, Lafayette, LA 70504-1010. *Stochastic juveile-adult models with application to a green tree frog population.*

We derive several stochastic models from a deterministic model that describes the dynamics of age-structured juveniles coupled with size-structured adults. Numerical simulations results of the stochastic models are compared with the solution of the deterministic model. These models are then used to understand the effect of demographic stochasticity on the dynamics of an urban green tree frog (Hyla cinerea) population. (Received September 22, 2010)

1067-92-1975 **Peng Zhong*** (zhong@math.utk.edu), Math Department, University of Tennessee, Knoxville, TN 37996, **Suzanne Lenhart** (lenhart@math.utk.edu), Math Department, University of Tennessee, Knoxville, 37996, and **Elsa Schaefer** (elsa.schaefer@marymount.edu). *Optimal Control of a Cholera Model by Vaccination.*

A model of Cholera with nine ordinary differential equations is built to track movement of susceptible individuals with and without partial immunities to either an asymptomatic infected class or a symptomatic infected class, then to two recovered classes with different waning rates. A vaccinated class is added into this model as well and the vaccination rate is a control function.

We look for an optimal vaccination rate that minimizes the economic and social losses, thus the objective functional is set to be the total asymptomatic infected together with weighted vaccination cost. We use 4th order Runge Kutta method for numerical results. How some sensitive parameters, like the ingestion rate of vibrios, could affect the vaccination suggestion is studied. (Received September 22, 2010)

1067-92-2016 **Andrew L Nevai*** (anevai@math.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816, and **Edy Soewono** (esoewono@bdg.centrin.net.id), Department of Mathematics, Institut Teknologi Bandung, Bandung, 40132, Indonesia. *A mathematical model for the spatial transmission of dengue in a periodic environment.*

In some parts of the world, dengue is transmitted from human to human through the bites of a female mosquito (*Aedes aegypti*). Strangely, these bites seem to occur only in daytime. Here, we use a system of periodic difference equations to study the dynamics of an epidemic in which hosts (humans) have daytime, but not nighttime, mobility and vectors (mosquitoes) have no mobility. The habitat consists of two patches and each day is divided into four parts: evening, dawn, daytime, and dusk. At dawn some hosts in each patch move to the other patch and at dusk those who survive return home. The basic reproduction rate ($\mathcal{R}_0$) of the disease is obtained and the impact of various kinds of host mobility on the disease-free and endemic equilibrium states are discussed. (Received September 22, 2010)

1067-92-2030 **Abra Brisbin*** (Brisbin.Abra@mayo.edu), Harwick 7, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, and **Liewei Wang** and **Brooke L. Fridley**. *Utilizing gene pathway-based priors in Bayesian association studies.* Preliminary report.

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 explore a range of possible Bayesian models to encode gene network structure as prior knowledge in a study associating phenotype with the expression levels of genes in the network. We test our models on simulated datasets and make recommendations about the best model to use in various situations. We use our models to analyze the effects of gene expression on IC50 for gemcitabine and thiopurine pharmacogenomic studies. We find that NT5C3 plays an important role in increasing resistance to gemcitabine, and NT5E decreases resistance to mercaptopurine. (Received September 22, 2010)

1067-92-2056 **Tracie McLemore Salinas*** (salinastm@appstate.edu), Department of Mathematical Sciences, Appalachian State University, Boone, NC 28608, and **Rene A. Salinas** (salinasra@appstate.edu). *Using Disease Models to Develop Teacher's Understanding of Modeling.*

As part of the professional development of the Teacher Algebra Network, an MSP grant, we explored modeling with teachers of grades 6-12. One of the workshops explored three representations of disease models: 1) Difference equations, 2) Digraphs, and 3) Excel spreadsheets. The idea was to demonstrate to teachers that there are numerous mathematically relevant approaches for studying one interesting topic. In this talk we will discuss the content of this workshop and how the adoption of the Common Core Standards by nearly 40 states provides a particularly opportune moment for developing teachers' understanding of modeling. (Received September 22, 2010)

1067-92-2111 **Sophia R.-J. Jang*** (sophia.jang@ttu.edu), Lubbock, TX 79409. *Competitive exclusion and coexistence in a Leslie-Gower competition model with Allee effects.* Preliminary report.

The classical competitive exclusion principle states that two populations competing for a limited resource cannot coexist, that one of the populations will drive the other to extinction. We prove in this work that when one population is also subject to Allee effects, then both competing populations may either coexist or one population may drive the other to extinction depending on initial conditions. (Received September 23, 2010)

1067-92-2170 **Michael G Kerckhove*** (mkerckho@richmond.edu), University of Richmond, Department of Mathematics & Computer Science, Richmond, VA 23173. *Stable Tissue Topology and Cell Division in 3D.* Preliminary report.

The study of geometric patterns in epithelial tissue, specifically as they relate to the distribution within the tissue of the number of cells surrounding a given cell, is of considerable interest in developmental biology. Gibson, Patel, Nagpal, and Perrimon (Nature 442, August 2006), employed a Markov model of cell division in order to predict convergence of epithelial topology to a fixed equilibrium distribution of cellular polygons. Motivated by this work, we model tissues consisting of polyhedral cells whose cleavage planes are randomly oriented, deriving a formula for the evolution of the mean number of vertices, edges, and faces in the tissue in terms of the expected number of cleavage plane-edge intersections per cell. We determine a value for this parameter that results in a stable equilibrium topology for the tissue. Invoking Erreras' Rule, the rule that the plane of division corresponds to the shortest path that will halve the volume of the mother cell, we show that the topology of the uniform tiling of space by truncated octahedra, in which the number of faces per cell is 14, is stable under cell division.
(Received September 22, 2010)

1067-92-2264 **Boloye Gomero*** (bgomero@utk.edu), 104 Aconda Court, 1534 Cumberland Ave., Knoxville, TN 37996. *Sensitivity Analysis Of a Cholera Epidemic Model.* Preliminary report.

Cholera is a water-borne acute diarrheal disease caused by infection of the human intestines by the bacterium Vibrio cholerea. The disease can be transmitted either directly by human-to-human contact (fecal-oral) or indirectly via environment-to-human contact (food and water-borne). Cause of death is mainly dehydration and in severe cases, without treatment, death may occur within hours of infection. Preventive measures include improved sanitation and water supply and more recently, oral vaccines.

Our preliminary study uses optimal control theory, parameter sensitivity analysis and numerical simulations to investigate the disease dynamics, thereby, providing a frame work for designing cost-effective control strategies.

Sensitivity Analysis is used to estimate the degree of confidence in our parameter estimates. The goal is to identify parameter values that are most influential in controlling disease dynamics. A Latin Hypercube Sampling (LHS) scheme is implemented and the LHS procedure assumes that the sampling executed for each parameter is independent.

The collaborators on this work include Peng Zhong, Dr. Renee Fister, Dr. Holly Gaff, Dr. Elsa Schaefer, and Dr. Suzanne Lenhart. (Received September 22, 2010)

1067-92-2284 **Shabnam Moobedmehdiabadi*** (mshabnam@gmail.com), Department of Mathematics, University of California Irvine, Irvine, CA 92697. *Lattice Gas Cellular Automata modeling of lineage dynamics and feedback control.*

We develop a general framework to model the dynamics of cell lineages. We specialize the model to lineages with two constituent, one that mimics the combined effect of stem cell (SC) and progenitor cell (CP) types while the other characterizes terminally differentiated (TD) cells. We first give a microscopic derivation of the model, then using averaging via mean field approximation, we give mesoscopic description of the model. We then derive a macroscopic description (PDE) of the model. We compare the approximations and investigate the speed and structure of invading front obtained by macroscopic PDE and associate LGCA models.
(Received September 22, 2010)

1067-92-2303 **Kara T Pham*** (karap@math.uci.edu), Department of Mathematics, 340 Rowland Hall, Irvine, CA 92697, and **Hermann B Frieboes**, **Vittorio Cristini** and **John Lowengrub**. *Predictions of tumor morphological stability and evaluation against experimental observations.*

The hallmark of malignant tumors is their invasion of local tissue and infiltration of distant organs (metastasis). A defining characteristic of aggressive tumors is an unstable morphology, including invasive fingers and protrusions. Shape instabilities (growing protrusions) are associated with local invasiveness, also often a precursor to tumor metastasis. We study tumor morphological stability by employing three mathematical models to gain insight into tumor invasion and metastasis. We consider three constitutive relations to describe tumor growth: Darcy's law, Stokes law, and the combined Darcy-Stokes law. Darcy's law is used to describe fluid flow in a porous medium. Stokes flow describes the flow of a viscous fluid. Using linear theory, we study the tumor morphological stability described by each model and evaluate the consistency between theoretical model predictions and experimental data from in vitro 3D multicellular tumor spheroids. We will discuss the results and further show that it is feasible to extract parameter values from a limited set of data and create a self-consistent modeling framework that can be extended to the multiscale study of cancer. Numerical methods are used to simulate the nonlinear effects of stress on solid tumor growth and invasiveness. (Received September 22, 2010)

1067-92-2332 **Amber C Xu*** (axu@andrew.cmu.edu), Carnegie Mellon University, SMC 3815, 5032 Forbes Ave., Pittsburgh, PA 15289. *Prelens Tear Film Evaporation from a Porous Layer.*

We study a fluid dynamic model of prelens tear film evaporation over a contact lens in the human eye. Our model is a one-dimensional combination of previous work on fluid film evaporation and thin film evolution on a porous layer. The model is solved numerically and validated with an analytical solution. We examine the effects of postlens tear film pressure, evaporation kinetics and pressure kinetics. Also investigated are the time required to reach a steady state tear film thickness and depletion of the postlens tear film. We find that varying the evaporation kinetics parameter produce evaporation rates comparable to measured values.

This work has been completed as a part of the 2010 REU Program at George Mason University funded by the NSF-REU and DOD-ASSURE Programs. (Received September 22, 2010)

1067-92-2335 **Srisairam Achuthan*** (sachut@lsuhsc.edu), 2020 Gravier Street, Suite D, New Orleans, LA 70112, and **Jianxia Cui** (cuijianxia@gmail.com), **Robert J. Butera** (rbutera@gatech.edu) and **Carmen C. Canavier** (ccanav@lsuhsc.edu), 2020 Gravier Street, Suite D, New Orleans, LA 70112. *The degree of phase locking observed in hybrid neural circuits can be explained using maps based on the phase resetting curve.*

For networks of intrinsic neural oscillators, phase locking can be predicted using a phase resetting curve (PRC) that measures the extent to which a perturbation at a given phase advances or delays the next spike. We use the PRC measured under the assumption of pulsatile coupling in an isolated model neuron and an open loop biological neuron to predict phase locking when these two repetitively spiking neurons are reciprocally coupled via the dynamic clamp experimental setup. The experimental results exhibit varying degrees of noisy phase locking and/or non-stationarity. A map constructed based on the PRCs of the two neurons can account for observed firing patterns in which no neuron fires more than twice consecutively. Slipping episodes in which one neuron fires an extra spike can be induced by noise or by a frequency mismatch. Adding noise to the map allows us to develop criteria to differentiate these cases. The continuity of the PRC constrains the fixed points of the map to an even number, and allows period drift in the biological neuron to induce bifurcations in the observed activity when fixed points annihilate one another. (Received September 22, 2010)

1067-92-2336 **Erica Johnson**, **Jennifer Ortiz** and **Omayra Ortega*** (omayra.ortega@asu.edu), Arizona State University, Mathematical & Natural Sciences, PO Box 37100, Phoenix, AZ 85069. *A Stochastic Model of Rotavirus Infection and Vaccination.* Preliminary report.

Rotavirus diarrhea causes a disproportionate amount of the world's childhood mortality. Approximately 611,000 children die each year due to complications of rotavirus infections. Rotavirus is the most common diarrheal infection for children under the age of 3. All children are born susceptible, but there are vaccines that may be utilized to decrease the risk of infection. In our study, we explored using a stochastic mathematical model to better demonstrate the transmission of the virus in detail. Our stochastic model is based on a deterministic ordinary differential equations model with 16 compartments. (Received September 22, 2010)

1067-92-2350 **Rosalyn C. Rael*** (rrael@umich.edu), Dept. of Ecology and Evolutionary Biology, 2004 Kraus Natural Sciences Bldg., University of Michigan, Ann Arbor, MI 48103, and **J. M. Cushing**, Department of Mathematics, 617 N. Santa Rita, University of Arizona, Tucson, AZ 85721. *Evolution and competitive coexistence in food chains.*

Using an evolutionary game theory approach, we combine ecological and evolutionary dynamics in a differential equation model to study the effects of trophic structure and competition on evolutionarily stable strategies (ESS) in food chains. We build food chains with three trophic levels where the predation rate depends on a body-size based preference function. Body size represents the strategy, or evolving trait, in this model.

We show how the addition of trophic levels in a food chain changes the equilibrium strategies of existing species. When a consumer is introduced, the equilibrium strategy of the basal species evolves toward a value that increases the intrinsic growth rate; however, this effect is buffered by predator species at the third trophic level. We also show how increasing the speed of evolution gives rise to cyclical dynamics that influence the number of basal species that can coexist. These results suggest that evolution is essential to understanding long term dynamics in trophic interaction networks that form the basis for large-scale food web models of ecosystems. (Received September 22, 2010)

1067-92-2370 **Christopher Brown** and **Sheila K. Miller*** (sheila.miller@colorado.edu), 646 Swift Road, West Point, NY 10996. *Predator-prey role reversal as bifurcation in a structured model.* Preliminary report.

Role reversal in predator-prey systems has been observed in multiple ecosystems, usually as a result of external factors leading to a change in the environment. We study a structured model in which predator-prey role reversal is a result of a change in density rather than external factors. We then compare our model to a one-parameter structured model in which predator-prey role reversal occurs as a bifurcation. (Received September 22, 2010)

1067-92-2375 **Aprillya Lanz*** (lanzAR@vmi.edu), 430 Mallory Hall, Lexington, VA 24450. *Mathematical Model of Methamphetamine and HIV Epidemics among Men-Seeking-Men Community.* Preliminary report.

Recent data suggest that methamphetamine use is on the rise and has been considered as an epidemic. Many studies have focused on the physiological and psychological issues related to methamphetamine use which found that the popularity of methamphetamine are due to the effects of intoxication in self-confidence, euphoria, increase sexual drive and appetite suppression. Because of the sexual drive side effect, the use of methamphetamine has been rapidly rising among the men-seeking-men community in which they practice risky sexual behavior. Thus, methamphetamine is a potential cause for the exacerbation of HIV epidemic in the men-seeking-men community. This presentation will discuss the mathematical model of the relationship between methamphetamine use and its effects on the HIV transmission among the men-seeking-men community. A modified cross-community SI model will be presented along with the analysis of the model that include the methamphetamine-HIV epidemic threshold, equilibria, and some numerical simulations. (Received September 22, 2010)

1067-92-2377 **Chuanbin Du*** (cdu@uncc.edu), 505 Barton Creek Dr. Apt J, Charlotte, NC 28262, **Hui Wang**, Charlotte, NC 28262, **Dennis Livesay**, Charlotte, NC 28262, and **Donald Jacobs**, Charlotte, NC 28262. *A Heterogeneous Adaptive Sparse Grid Method For Representing High Dimensional Free Energy Landscape in Proteins.*

The free energy landscape (FEL) is very important for quantitatively studying and understanding the relationships between structure, dynamics, stability, and functional behavior of proteins. However, the free energy landscape of a protein is a high-dimension hyper surface and is difficult to rationalize. Here, we developed an adaptive sparse grid method, which can detect important dimensions, identify and resolve singularities and local non-smooth variations in high dimensional functions. This method provides an accurate and efficient approach for the computation of the representation of the free energy landscape of proteins. (Received September 23, 2010)

1067-92-2381 **Mohammed Yahdi*** (myahdi@ursinus.edu), Department of Mathematics & Computer Science, Ursinus College, Collegeville, PA 19426, and **Sara Abdelmageed**, **Jon Lowden** and **Lloyd Tannenbaum**. *Modeling, Analysis and Outbreak Risk of Vancomycin-Resistant Enterococci.* Preliminary report.

We developed and analyzed a new deterministic mathematical model of Vancomycin-Resistant Enterococci (VRE) infested intensive care unit (ICU). This model consists of five non-linear differential equations with five variables based on the patient stages of VRE infection: susceptible, colonized, colonized with preventative care, infected, and infected undergoing treatment. We investigated the dynamics between those five infection stages under the effect of nineteen independent parameters. The parameters include colonization rate, fitness cost, plasmid transfer, antibiotics use, preventive care, treatment schedule and infection factors. The parameter values vary within determined specific ranges to account for any ICU scenario.

Simulations were created and normalized impacts of the parameters were measured revealing strategies to control VRE infections. Furthermore, disease free analysis was performed to compute the basic reproduction rate, related sensitivity analysis, and bifurcation diagrams to investigate the outbreak risk and the best preventive strategies without the risk involved in clinical testing. The model highlighted the parameters with the largest impact and quantified the values that minimize outbreak risk. (Received September 23, 2010)

93 ▶ Systems theory; control

1067-93-361 **Billy Jackson*** (bjackson@sxu.edu). *Fundamentals of Nonlinear Control on Time Scales.* Preliminary report.

Based upon earlier joint work with others done by the author in stability theory for linear and nonlinear systems, we examine crucial aspects of control for nonlinear systems. This includes basic criteria for nonlinear systems to be controllable, observable and realizable. Examples will be given to indicate the utility of such an analysis, particularly on non-uniformly spaced domains. (Received August 27, 2010)

1067-93-515 **Frederic Mazenc**, Projet INRIA DISCO, CNRS-Supelec, 3 rue Joliot Curie, 91192, Gif-sur-Yvette, France, **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, Louisiana State University, 303 Lockett Hall, Baton Rouge, LA 70803-4918, and **Marcio de Queiroz**, Department of Mechanical Engineering, Louisiana State University, Baton Rouge, LA 70803-6413. *Adaptive Tracking and Estimation for Nonlinear Control Systems.*

Given a nonlinear system

$$\dot{\mathbf{q}} = \mathcal{J}(t, \mathbf{q}, \mathbf{\Theta}, \mathbf{u}), \tag{1}$$

having a vector $\mathbf{\Theta}$ of uncertain constant parameters and a reference trajectory $\mathbf{q}_r$ and a suitably regular right hand side, the *adaptive tracking and estimation problem* is to design a dynamic feedback

$$\mathbf{u} = \mathbf{u}(t, \mathbf{q}, \mathbf{\Theta}_e), \quad \dot{\mathbf{\Theta}}_e = \tau(t, \mathbf{q}, \mathbf{\Theta}_e) \tag{2}$$

such that $\mathbf{q}_r(t) - \mathbf{q}(t) \to 0$ and $\mathbf{\Theta} - \mathbf{\Theta}_e(t) \to 0$ as $t \to +\infty$ for all initial conditions. I will present a brief survey on the known results for this problem. Then I will discuss a new family of dynamic feedbacks that solve the adaptive tracking and estimation problem for a class of systems that are affine in $\mathbf{\Theta}$. (Received September 11, 2010)

1067-93-804 **Shaobai Kan*** (skan@jjay.cuny.edu), 445 W. 59th Street, Room 4226N, New York, NY 10019, and **George Yin**. *Identification of Regime-Switching Systems with Structural Uncertainties.*

This work develops persistent identification of regime-switching systems that are subject to not only measurement noise, but also structural uncertainties such as unmodeled dynamics, sensor nonlinear mismatch, and observation bias. We consider two classes of problems. In the first class, the switching parameters are stochastic processes modeled by irreducible and aperiodic Markov chains with transition rates much faster than adaptation rates of the identification algorithms. Instead of tracking real-time parameters by output observations, we are devoted to investigating the average behavior of the parameter process. Identification error bounds are established and analyzed for their dependence on these structural uncertainties. In the second class of problems the parameters systems vary infrequently. An adaptive algorithm with variable step sizes is introduced for tracking the time-varying parameters. Numerical results are presented to illustrate the performance of the algorithm. (Received September 17, 2010)

1067-93-1686 **Ahmet Ozkan Ozer*** (oozer@iastate.edu), 403 Carver Hall, Iowa State University, Ames, IA 50011. *Exact Controllability of a Rayleigh beam with a single boundary control.*

We consider the boundary controllability problem for a Rayleigh beam. We obtain exact controllability with a single boundary control in the optimal control time. Our result improves earlier results in the literature which require either additional controllers (e.g. two controls at one end or one control at each ends), or an additional uniqueness assumption. Our approach combines the multiplier method with results from nanharmonic Fourier series due to Haraux and Komornik. (Received September 21, 2010)

1067-93-1930 **John M Davis*** (John_M_Davis@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798. *Asymptotic Equivalence Classes and Regions of Time Scale Exponential Stability.* Preliminary report.

We present the notion of asymptotic equivalence classes for time scales and show how they can be used to characterize the regions of time scale exponential stability studied by Pötzsche, Siegmund, and Wirth. (Received September 22, 2010)

1067-93-1956 **Radu C Cascaval*** (radu@uccs.edu), Department of Mathematics, 1420 Austin Bluffs Parkway, Colorado Springs, CO 80918. *Autoregulation Mechanisms in Complex Networks.*

The dynamic control of spatial networks presents numerous challenging problems, both theoretically and computationally. Here we present a study of the cerebral autoregulation (CA) mechanism in the cardiovascular network, in which both the heart rate (HR) variability and the peripheral resistance (PR) variability act as controls for the pressure and flow rates throughout the system, with the aim of maintaining constant flow in the brain during dynamic changes. The dynamics of the network is characterized by distinct patterns of the nonlinear pressure and flow distribution, and related inverse problems will be presented. Furthermore, we will discuss evidence that the complexity of the underlying network and the presence of different scales in the model influences the effectiveness of these control mechanisms. (Received September 22, 2010)

1067-93-2301 **John Teye Brown*** (jtbrown@latech.edu), 318 W. Louisiana Ave., Apt 11, Ruston, LA 71270. *Discrete-Time Sensitivity Analysis for MinMax Parameter Choice for the Heat Equation.*

The goal of this work is to minimize the computational cost associated with the experimental determination of the critical parameter used in the design of the MinMax controller. To this end, the sensitivity of the controlled state to variations in the parameter is examined mathematically using Discrete-Time sensitivity equations. The sensitivity of the controller's performance, robustness and convergence with respect to the parameter is also studied. By analyzing these various sensitivities, it is hoped that a mathematically justified parameter can be determined. (Received September 22, 2010)

94 ► Information and communication, circuits

1067-94-740 **Hiroyuki Okazaki*** (okazaki@cs.shinshu-u.ac.jp), Shinshu University, Graduate School of Science and Technology, 4-17-1 Wakasato, Nagano, Nagano 380-8553, and **Yasunari Shidama** and **Yuichi Futa**. *Formal Definition of Probability and Probabilistic Function on Finite and Discrete Sample Space for Proving Security of Cryptographic Systems Using Mizar.*

In recent studies, many researchers have attempted to verify the security of cryptographic systems using computer- assisted proof tools. For example, Certicrypt and Cryptoverif are well-known frameworks in this context. However, these proof tools are insufficient for proving the security of some cryptographic systems, because the tools specialize in the game-based proof method. Thus, in this study, we attempt to formalize essential elements of cryptology, number theory,computational complexity, and probability etc. We then also encode them in Mizar system. In this report, we briefly introduce the importance of which probability and probabilistic functions in cryptology. Further, we present our formal definition of probability and probabilistic function on a finite and discrete sample space in Mizar. (Received September 14, 2010)

1067-94-1311 **Somantika Datta*** (sdatta@uidaho.edu), Department of Mathematics, Brink Hall Room 300, Moscow, ID 83844-1103. *Construction of zero autocorrelation stochastic waveforms.* Preliminary report.

Designing unimodular sequences with an impulse-like autocorrelation is central in the general area of waveform design, and it is particularly relevant in several applications in the areas of radar and communications.

We first construct discrete infinite sequences from certain random variables such that the expected autocorrelations of the sequences have spike like behavior. By using Brownian motion this approach is then extended to the construction of continuous functions, instead of sequences, with similar behavior of the expected autocorrelation. The stochastic and non-repetitive nature of the waveforms means that they cannot be intercepted or detected by an adversary. However to be effective, the variance of the autocorrelation also needs to be small. This is part of the ongoing assessment. (Received September 20, 2010)

1067-94-1345 **P. Laverty*** (patricia.laverty@richmond.edu), Richmond, VA 23173, **S. Alzouma**, Richmond, VA 23173, and **W. Lambdin**, Richmond, VA 23173. *Applications of discrete wavelets.*

In this talk, we will present two applications of discrete wavelets. The first is a de-noising of a original sound file of J. Brahms. The second is predicting stock values. We will introduce the basics of discrete wavelets and then move on to the applications. (Received September 20, 2010)

1067-94-1354 **Mrinal Kanti Roychowdhury*** (roychowdhurymk@utpa.edu), Dept of Math, UTPA, 1201 West University Drive, Edinburg, TX 78539. *Quantization dimension for an infinite iterated function system.*

Quantization for probability distributions concerns the best approximation of a d-dimensional probability distribution P by a discrete probability with a given number of n-supporting points or in other words, the best approximation of a d-dimensional random vector X with distribution P by a random vector Y with at most n values in its image. The random vector Y which gives the error minimum is called the optimal quantizer of the random vector X and the corresponding error is called the optimal error. The image set of the optimal quantizer is called the optimal set. One of the main goal of quantization theory is to estimate the rate called 'Quantization dimension' at which the specified measure of the error goes to zero as n increases.

In this talk, I will show how to determine the quantization dimension function for a probability measure generated by an infinite iterated function system. A relationship between the quantization dimension and the temperature function of the thermodynamic formalism is also established. (Received September 20, 2010)

1067-94-1716 **Michael E O'Sullivan*** (mosulliv@math.sdsu.edu), Dept of Mathematics and Statistics, San Diego State University, San Diego, CA 92120, and **John Brevik**. *The sum-product algorithm for binary codes having check nodes of degree two.*

The sum-product algorithm for decoding of binary codes is analyzed for bipartite graphs in which the check nodes all have degree 2. The algorithm simplifies dramatically and may be expressed using linear algebra. Exact results about the convergence of the algorithm are derived and analysis of the sum-product algorithm on trapping sets is given. (Received September 21, 2010)

1067-94-1917 **Ali Saleh Shaqlaih*** (ali.shaqlaih@unt.edu), Dept. Of Mathematics and Information Sciences, University Of North Texas at Dallas, 7300 Houston School Road, Dallas, TX 7524, and **Luther White** and **Musharraf Zaman**. *Resilient Modulus Modeling by Neural Network Models with Information Theory Approach.* Preliminary report.

Neural network models have been developed to correlate resilient modulus with routine properties of subgrade soils and state of stress for pavement design application. An information theory approach is taken as a method in deciding the best model. This approach is compared with the R^2 approach. The notion of ranking stability is introduced and is used as one of the reasons that makes information theory approach better than the R^2 approach. A short overview of the information theory approach is introduced. (Received September 22, 2010)

1067-94-2177 **Todd Wittman*** (wittman@math.ucla.edu), 10747 Wilshire Blvd #1404, Los Angeles, CA 90024. *Image and Data Fusion.*

A visual image is often accompanied by non-visual information about the scene. For example, one may have census or poll data that fits a geographic region captured in a satellite image. A mathematical challenge is to combine the image and data in a sensible manner. I will present recent work on fusing image and event data in a variational framework. I will also show two of our current image fusion projects, one on fusing near-shore oceanographic images with bathymetry data and another on incorporating physics models into video tracking of airborne gases. (Received September 22, 2010)

97 ► Mathematics education

1067-97-12 **Alexander Y Vaninsky*** (avaninsky@hostos.cuny.edu), 500 Grand Concourse, Room B-409, Bronx, NY 10451. *Impact of Automated Proof Systems on Teaching Mathematics.*

Recent developments in the systems of automated proof pave the way to a new approach to teaching mathematics. Such systems allow for hypothesizing theorems with their proof or disproof performed by computer software. This environment allows for change in the pedagogy of mathematics education by making more stress on the logic of the proofs and mathematical objects under consideration. In the framework of the suggested approach each topic of mathematics curriculum is considered a class equipped with properties and methods. Theorem proof is an automated process of assigning values to specific properties. Such approach stresses the basic notions and concepts of mathematics while eliminating routine lengthy proofs. For example, the Göedel Incompleteness Theorem may become a regular topic of standard high school or undergraduate mathematics courses. Students' mathematics preparation should include understanding of the main principles of the automated proof and ability to simulate their functioning. It is shown that a well-known table -based approach to problem solving may serve as a means of simulation while connecting puzzles to proofs. An example of application of the suggested approach is demonstrated. Possible impact on mathematical pedagogy is discussed. (Received April 23, 2010)

1067-97-58 **Steven J Cox*** (cox@rice.edu), CAAM MS 134, Rice University, 6100 Main, Houston, TX 77005, and **Jessica C Joyce**, **Kathryn Ward** and **Jay Raol**. *WRAP - The Worthing Rice Apprenticeship in Computational Neuroscience.*

WRAP is an outreach effort between Rice University and Worthing High School in Houston TX. We exploit the student's native fascination with the brain to develop skills in both the mathematical modeling of brain function and the computational analysis of neural data. With respect to modeling our students build networks of Boolean neurons and so gain concrete experience with adjacency matrices and interpret matrix-vector products in terms of the propagation of activity through a network. With respect to the analysis of neural signals our students learn statistical methods in order to detect salient features in Electroencephalogram data coming from both normal and diseased individuals. The apprentices conduct this work at Rice during weekly 3 hour sessions, in MATLAB, under the guidance of dedicated undergraduate and graduate mentors. In this talk we survey the content covered and discuss the leverage provided by a computational environment that provides students with the ability to simulate and visualize complex phenomena. (Received July 05, 2010)

1067-97-70 **Anna E Bargagliotti*** (abargag@yahoo.com), **John Haddock**, **Fernanda Botelho** and **Jim Gleason**. *The Effectiveness of Blended Instruction in Postsecondary General Education Mathematics Courses.*

Students who pursue a postsecondary baccalaureate degree are required to complete at least one general education mathematics course. Low student success rates in these courses are pervasive, and there is a need to improve student success and retention in general mathematics.

In this paper, we report results comparing the impact of the Memphis Mathematics Method (MMM), a blended learning instructional model to the traditional lecture teaching method on student performance and retention in general education mathematics courses. The comparison of approximately 10,000 students occurs in College Algebra, Foundations of Mathematics, and Elementary Calculus at the University of Memphis from Fall 2007 to Spring 2010. Results indicate the MMM is effective in increasing student achievement and retention. (Received July 09, 2010)

1067-97-81 **Mark L. Daniels*** (mdaniels@math.utexas.edu), Mathematics Department, 1 University Station C1200, Austin, TX 78712, and **Efraim P. Armendariz** (efraim@math.utexas.edu), Mathematics Department, 1 University Station C1200, Austin, TX 78712. *How the Mathematics Department Supports the UTeach Program in the College of Natural Sciences at the University of Texas at Austin.*

The UTeach Secondary Mathematics and Science Teacher Certification program at the University of Texas at Austin is a nationally recognized and replicated model for preservice teacher preparation. The UTeach program is housed within the College of Natural Sciences, and students in the program are all majors within the College. This presentation will detail how the Mathematics Department at the University of Texas supports, develops courses for, and collaborates with the UTeach program in order to provide a meaningful and coherent experience for the mathematics majors who are also seeking secondary teacher certification as part of their undergraduate degree plan. Some time will also be allocated to discuss how the Mathematics Department supports the UTeach Summer Master of Arts program for working secondary teachers. (Received July 20, 2010)

1067-97-134 **Todd Wittman*** (wittman@math.ucla.edu), UCLA Department of Mathematics, Box 951555, Los Angeles, CA 90095. *The UCLA Applied Math REU Program.*

The UCLA REU program is a NSF-funded summer program that employs undergraduate students for 8 weeks to work on research topics in applied math. The projects have covered diverse topics such as image processing, fluid dynamics, math finance, math biology, and crime modeling. A key feature of this program is that the research topics are intertwined with larger research tracks of UCLA faculty. Many of the projects have led to published papers and have been picked up by UCLA PhD students for their dissertation research. I will describe my involvement with the program as a mentor, describe some of the recent REU projects, and relate my experience of what works best in organizing an REU program. (Received July 27, 2010)

1067-97-152 **Padmanabhan Seshaiyer*** (pseshaiy@gmu.edu), 4400, University Drive, MS:3F2, Science and Tech I, Mathematical Sciences, George Mason University, Fairfax, VA 22030, and **Jennifer Suh**. *GMU COMPLETE: Center for Outreach in Mathematics Professional Learning and Educational Technology.* Preliminary report.

The COMPLETE center at George Mason University (GMU) provides a collaborative network that brings together a consortium of school district leaders, K-12 teachers, GMU Faculty and students, national experts, non-profit organizations and business partners to promote excellence in mathematics teaching, learning and collaborative mentoring in Northern Virginia through innovative solution-oriented initiatives and technology integration.

In this talk, we will present professional development and enrichment opportunities that include developing STEM based educational programs for students and teachers to solve real-world problems that focus on 21st Century Skills including critical thinking, problem solving, communication, collaboration and creativity, careers, technology and innovation; providing sustained, intensive and high-quality K-12 teacher mathematics professional development and; providing targeted opportunities for meaningful mathematics learning to underrepresented populations in STEM Education Initiative. (Received July 27, 2010)

1067-97-175 **James R. Valles Jr*** (james.valles@ttu.edu), TTU Mathematics, Math Bldg., Room 201, Box 41042, Lubbock, TX 79409-1042, and **Rebecca Ortiz** (Rebecca.Ortiz@ttu.edu), Texas Tech University, College of Education, Box 41071, Lubbock, TX 79409-1071. *Prospective Teachers' Self-assessment Based on Reflective Writing Assignments in a Pre-service Math Course.* Preliminary report.

At Texas Tech University, MATH 3370 (Elementary Geometry) is a course designed to provide prospective elementary and middle school teachers with a basic background in elementary geometry, probability, and statistics. In one recent semester, I required reflective writing assignments that asked the future teachers to discuss how they would approach and handle different possible scenarios in their early teaching careers.

This talk is a discussion of some responses received in the writing assignments from the students in my class. I will present and discuss some of the responses submitted with respect to the appropriate writing prompt. Of particular interest are the reflective attitudes presented by the students toward their mathematical knowledge and ability to teach mathematics. The students' view of their mathematical competency and enthusiasm toward math will also be discussed. (Received July 28, 2010)

1067-97-183 **Robert Bozeman*** (rbozeman@morehouse.edu), Department of Mathematics, Morehouse College, Atlanta, Georgia 30314. *Increasing the pool of underrepresented mathematicians.*

The speaker will draw upon his thirty-seven years of teaching collegiate mathematics to African American males to discuss strategies that may increase the number of minority mathematicians. Some of the strategies to be examined will be extracted from departmental strategic plans. Additionally, the speaker will examine strategies that are embedded in institutional scholars programs as well as some that have been used by influential mathematics professors in encouraging students to pursue graduate degrees in mathematics. The talk will emphasize those strategies that may be replicated at other colleges and universities. (Received July 29, 2010)

1067-97-268 **Ira Gerhardt*** (ira.gerhardt@manhattan.edu), Dept of Mathematics and Computer Science, Manhattan College, 4513 Manhattan College Parkway, Riverdale, NY 10471. *The ALARM Experiment.* Preliminary report.

During a recent semester, an experiment was performed to test the theory that the greatest difficulty students must overcome in completing an introductory Calculus course is being ill-prepared in terms of their comfort with basic algebraic and arithmetic concepts and techniques. It appears the most blatant cause of this discomfort is the reliance on calculators and the hesitancy of instructors during the students' junior high and high school years to reinforce sufficiently concepts such as order of operations as well as techniques for working with fractions, negative numbers, and radicals. The experiment found that nearly 40% of students sacrificed at least one-third of a letter grade specifically to these algebraic and arithmetic mistakes (rather than to difficulty with Calculus or carelessness). (Received August 15, 2010)

1067-97-550 **Rick Gillman*** (rick.gillman@valpo.edu), 1900 Chapel Drive, Valparaiso, IN 46383. *Reorganizing School Mathematics for Quantitative Literacy.*

This paper proposes replacing the Algebra-Geometry-Algebra rush to calculus model with one which focuses on improving student problem-solving skills and general quantitative literacy skills while reinforcing basic manipulative skills. Most of these goals are gained by expanding the current single year algebra course into a two year course. The model proposes moving "learning to write proofs" from the traditional geometry course into a separate discrete mathematics course. It requires statistics for every student, and requires a senior-level modeling course for every college going student. In addition, the proposed model creates opportunities for students to move at their own pace through the program by organizing courses in semester units rather than year-long units. (Received September 09, 2010)

1067-97-645 **Robert Lee Mayes*** (rmayes2@uwyo.edu), Department 3992, 1000 E. University Avenue, University of Wyoming, Laramie, WY 82071. *University of Wyoming Science and Mathematics Teaching Center: Report on Mathematics Teaching, Education, and Outreach through a joint unit of College of Arts and Sciences and College of Education.* Preliminary report.

This presentation on the University of Wyoming Science and Mathematics Teaching Center (SMTC) is part of the Special Session on Centers for Teaching/Education/Outreach in Departments of Mathematics. The SMTC is unique in that it is a joint unit in the College of Arts and Sciences and the College of Education. This allows the SMTC to create collaborative efforts between UW and Wyoming school districts that provide for content-based professional development for K-12 STEM teachers. The professional development engages mathematicians, mathematics educators, scientists and science educators in working with STEM teachers to improve both their content understanding and teaching practice. The professional development includes master's programs for middle school mathematics and secondary school mathematics, grant funded workshops for STEM teachers, and conferences/speakers centered on mathematics education. Current projects include: NSF Math Teaching Learning Center project which is creating a multi-university online master's degree program for secondary mathematics teaching; NSF Pathways project with a focus on quantitative reasoning in developing environmental literacy; MSP QR STEM project focusing on interdisciplinary study of energy and environment with mathe underpinnings. (Received September 12, 2010)

1067-97-725 **Lawrence S. Moss*** (lmoss@indiana.edu), Math/ Rawles Hall 323, 831 E. Third St, Bloomington, IN 47405. *Applied Logic Courses in the Mathematics Curriculum.*

By 'applied logic' I mean the parts of logic that are inspired by, or developed in connection with, some subject which is outside of mathematics. The most application area is computer science, but there are other important ones including linguistics and areas in the social sciences. The topic is mathematics and logic, but it is not really mathematical logic in the usual sense.

I have been developing courses that could be called applied logic for some time. My talk will share my experiences with some of them, and also mention possible courses that others might like to try.

The overall point is that courses in applied logic could serve as highly stimulating mathematics courses, both for majors and non-majors. (Received September 14, 2010)

1067-97-739 **Emel Demirel*** (demirele1@mail.montclair.edu), 112 Hamilton Ave, Hasbrouck Heights, NJ 07604, and **Aihua Li**. *Study of Polynomial Solutions to Certain Diophantine Equations.*

In this paper, we investigate a particular Diophantine equation, $X^2 + Y^3 = 6912Z^2$, and a set of solutions to the equation, which are derived from some polynomials in $\mathbf{Z}[x, y]$. We focus on three polynomials $X = f(x, y), Y = g(x, y)$ and $Z = h(x, y)$ that satisfy the Diophantine equation and the greatest common divisors for the the integer values of the polynomials. These polynomials are relatively prime in $\mathbf{Q}[x, y]$. However, for a fixed integer pair x_0, y_0, the integer values $f(x_0, y_0), g(x_0, y_0)$ and $h(x_0, y_0)$ are not necessarily relatively prime in $\mathbf{Z}[x, y]$. We investigate the greatest common divisors (GCDs) between these three polynomial values for specific integer pairs x_0 and y_0. We focus on the cases where $y = 1$ and $y = 2$. For these cases, we give complete classifications on the distribution of the GCDs. We use the Gröbner Bases technique as an aid in investigating the GCDs for f, g, h in $\mathbf{Z}[x, y]$. We then generalize the results from the cases $y = 1$ and $y = 2$ to obtain similar properties for the GCDs of f, g, h for all x and y in $\mathbf{Z}[x, y]$. (Received September 17, 2010)

1067-97-755 **Steven William Anderson*** (steven.anderson@unco.edu), MAST Institute, The University of Northern Colorado, Greeley, CO 80639. *New Goals and Associated Changes at the Mathematics and Science Teaching (MAST) Institute at the University of Northern Colorado (UNC).*

MAST recently implemented significant changes to better position itself for influencing STEM education on a regional and national level. Originally designed to support and coordinate the STEM preparation of students and teachers, MAST has struggled to maintain its historically strong influence in northern Colorado. In 2007 under a new director, MAST refocused its mission to concentrate on a single goal; to assemble a support team that allows UNC faculty and off-campus partners to engage in a range of mathematics and science education outreach and research projects not previously possible at UNC, or at other competing institutes of higher education. To accomplish this objective, 2 state-funded positions were reclassified, and new hires now accomplish duties tied to these goals. Three critical soft-money positions now assist faculty with project develop. These changes allowed us to increase our external funding by over 20-fold and support a number of highly visible research, outreach, and scholarship/internship programs that reflect well upon the university. We are working with a record number of UNC STEM faculty and off-campus partners. A key element in attracting the best personnel involved writing contracts that allowed for supplemental grant work. (Received September 14, 2010)

1067-97-916 **Warren W. Esty*** (westy@math.montana.edu), Department of Mathematical Sciences, Montana State University, Bozeman, MT 59717. *A course emphasizing mathematical logic and reasoning that is appropriate for general education and elementary education majors.*

Mathematics is a language in which mathematics is written and thought. Like other languages, it has symbols, vocabulary, grammar (principles which govern its correct usage), synonyms, negations, conventions, abbreviations, and sentence structure. Some of its paragraphs are called proofs and they employ logic.

This talk describes a 100-level course called "The Language of Mathematics," originally designed for math majors, that turned out, somewhat surprisingly, to be remarkably good for non-math majors including elementary education majors. Although the elementary education majors in the course typically do not love algebra, they became very good at some high-level algebra and reasoning skills.

The goal is for the students to become fluent in the symbolic language of mathematics so they can efficiently read, write, learn, and think mathematical thoughts. Proofs occur occasionally throughout and are the focus at the end. Research shows that even students who are not mathematically inclined develop abstract mathematical concepts normally taught only to advanced college math students, and they enjoy doing it. (Received September 16, 2010)

1067-97-935 **Troy J Siemers*** (siemerstj@vmi.edu), 437 Mallory Hall, Virginia Military Institute, Lexington, VA 24450, and **Daniel S Joseph** and **Gregory N Hartman**. *A New Paradigm in Collaborative Textbook Writing.*

In this talk we will discuss the current author/publisher/student textbook paradigm and present an alternative. With software such as LaTeXand affordable online based print-on-demand services, faculty can work together to present their students with inexpensive, yet high quality, textbooks and course books that can be tailored to fit specific needs. We will introduce the APEX (Affordable Print and Electronic teXtbook)Project, a consortium of authors who collaborate to produce open textbooks. (Received September 16, 2010)

1067-97-1001 **Peter R Turner*** (pturner@clarkson.edu), School of Arts & Sciences, Clarkson University, 8 Clarkson Avenue, Potsdam, NY 13699-5800. *Applied Mathematics and High School Outreach: Opportunities and Resources.*

This introductory talk will provide an overview of some of the ways in which applied mathematics and modeling content can be incorporated into (middle and) high school programs. The use of contests has proved a valuable motivator. Some of these contests and their effect on student performance will be presented. Other resources that are available to students and their teachers will also be described. With the increased flexibility in mathematics curricula under the proposed common core standards, the inclusion of modeling and applications is likely to be of growing importance in the next few years. (Received September 17, 2010)

1067-97-1166 **Thomas W Judson*** (judsontw@sfasu.edu), Department of Mathematics and Statistics, Stephen F. Austin State University, P.O. Box 13040-3040 SFA Station, Nacogdoches, TX 75962, **Lesa L Beverly**, Department of Mathematics and Statistics, Stephen F. Austin State University, P.O. Box 13040-3040 SFA Station, Nacogdoches, TX 75962, and **Kimberly M Childs**, Department of Mathematics and Statistics, Stephen F. Austin State University, P.O. Box 13040-3040 SFA Station, Nacogdoches, TX 75962. *The Texas Leadership Initiative and Texas LIMIT Projects: Training the Trainers.* Preliminary report.

The Texas Leadership Initiative and Texas Leadership Initiative: Mathematics Instruction Transformed (Texas LIMIT) Projects, conducted through the Stephen F. Austin State University (SFASU) STEM Research and Learning Center, are NSF-sponsored programs to develop effective mathematics teacher leaders within high needs districts across East Texas. The objectives of these projects include developing leadership skills through: (1) training in differentiated instruction designed for diverse populations within schools; (2) training in the development and delivery of quality professional development within respective districts; (3) assisting in the assimilation and development of modules/materials; and (4) studying the effectiveness of efforts to train teacher-leaders. We will present an overview of the SFASU STEM Research and Learning Center together with the Leadership and LIMIT projects. (Received September 19, 2010)

1067-97-1214 **Deborah Hughes Hallett*** (dhh@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721. *Mathematical Literacy and Quantitative Literacy: Symbiosis or Competition?*

What is the difference between mathematical literacy and quantitative literacy? Does quantitative literacy necessarily follow from mathematical literacy? Should high schools focus only on mathematical literacy or should quantitative literacy have a place also? This talk will argue that quantitative literacy does not necessarily result from mathematical literacy and discuss how to develop quantitative literacy in an already full high school curriculum. (Received September 20, 2010)

1067-97-1221 **Brian Beaudrie*** (bbeaudrie@winona.edu), Department of Mathematics and Statistics, 175 West Mark Street, 305 Gildemeister Hall, Winona, MN 55987, **Emily Ricard**, Concord, NH, **Greg Superchi**, Lisbon, NH , and **David Gilcreast**, Pelham, NH. *Quantitative Literacy and the "Big Ideas" of High School Mathematics.*

By the time most students begin high school, they have been exposed to a large majority of the mathematical content and concepts necessary to function in society as quantitatively literate adults. Therefore, it would seem that the role of the high school in developing quantitative literacy among its students is to apply this mathematical knowledge to scenarios where quantitative reasoning would play a central role, while at the same time continually refining the students' knowledge of these necessary mathematical concepts.

The "big ideas" of quantitative literacy for high school students include developing number sense, problem solving skills, and the abilities to communicate and represent ideas mathematically. In developing these abilities among the students, by using examples and models consistent with the major themes of quantitative literacy (involving real-life situations, synthesizing several mathematical skills, etc.), a high school should produce graduates who are quantitatively literate. This presentation will discuss these ideas, and discuss the steps that one state has undertaken in order to develop the quantitative abilities of all of their students. (Received September 22, 2010)

1067-97-1237 **Deborah Hughes Hallett*** (dhh@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721. *The Power of Interdisciplinary Bridges: Throwing the Net Widely.*

Some students are fascinated by the elegance of mathematics. Others are captured by the connection between mathematics and other fields—science, art, business, or medicine. These interdisciplinary links are important for our own teaching; they are equally important in the K-12 classroom. Perhaps surprisingly, for many students, seeing mathematical ideas in context deepens their mathematical intuition—as well as their appreciation of the power of mathematics. These links provide a vehicle for teachers teaching to the Common Core State Standards, in which fluent understanding is key. For us, interdisciplinary connections provide a bridge for collaboration with K-12 teachers in workshops that explore mathematics in other fields. In this talk, we will look at ways to use interdisciplinary bridges and talk about how develop them, with examples from climate change, oil production, the spread of disease, racial profiling, and drug testing. (Received September 20, 2010)

1067-97-1252 **Hugo Rossi*** (rossi@math.utah.edu), 155 South 1400 East, Room #233, University of Utah, Salt Lake City, UT 84112-0090. *Items for Assessment of Mathematical Content Knowledge for Secondary Teachers.*

We give an account of the work of participants in a workshop on content knowledge of secondary teachers in the context of a set of problems, chosen so as to reveal the deeper content needed to understand and explain solutions. (Received September 20, 2010)

1067-97-1278 **Katie R Fowler*** (kfowler@clarkson.edu), 8 Clarkson Avenue, Department of Mathematics, Box 5815, Potsdam, NY 13676, and **Aaron Luttman**. *Math Modeling for Middle School Students.*

It is becoming more accepted that students need to be able to solve open-ended, real-open problems. As stated by many funding agencies, our future workforce needs to be able to solve problems that are not yet even imaginable. However, students are not often exposed to mathematical modeling at an early age and may not consider open-ended problems even at the undergraduate level. To this end, we describe a professional development workshop for local teachers to promote problem solving with mathematical modeling in a context relevant to middle school students. We discuss not only content, but challenges in implementing practices in the classroom. Ultimately, we hope to show that these activities enhance not hinder meeting state and national standards in mathematics while engaging students in integrated STEM curriculum. (Received September 20, 2010)

1067-97-1307 **Eric C Gaze*** (egaze@bowdoin.edu), 8700 College Staton, Bowdoin College, Brunswick, ME 04011. *The Role of QL in the High School Mathematics Curriculum Panel Discussion.*

The special session on Mathematics and Education Reform: "The Role of QL in the High School Mathematics Curriculum", will conclude with a panel discussion featuring the invited speakers for the session. This session is a collaboration between the Mathematics and Education Reform group and the MAA Special Interest Group in Quantitative Literacy (SIGMAA-QL). The panel discussion will allow for a more in depth question and answer period on this topic. (Received September 20, 2010)

1067-97-1443 **Adam Naumowicz*** (adamn@math.uwb.edu.pl), Institute of Informatics, University of Bialystok, ul. Sosnowa 64, 15-887 Bialystok, Podlaskie, Poland, and **Artur Kornilowicz** (arturk@math.uwb.edu.pl), Institute of Informatics, University of Bialystok, ul. Sosnowa 64, 15-887 Bialystok, Podlaskie, Poland. *Mizar-supported maths teaching at the university level.*

In this talk we will demonstrate the potential of using the Mizar system and its library of formalized mathematics as an aid in constructing university-level maths courses. We will present various methodologies and tools used to carry out and evaluate such courses. Several examples of Mizar-based courses will be shown in more detail. In particular, we will describe the pros and cons of developing courses based on the current contents of the Mizar Mathematical Library versus building customized fragmentary local libraries. (Received September 21, 2010)

1067-97-1548 **Michelle J Montgomery*** (montgomery@siam.org), 3600 Market St, 6th Floor, Phila, PA 19008. *Math Modeling for high school students: Moody's Mega Math Challenge as educational outreach.*

Moody's Mega Math Challenge is an Internet-based, applied math competition for high school juniors and seniors. Now in its sixth year, the competition is free to register and participate, and is open to high schools in 18 states along the East Coast. Winners receive scholarships totaling $100,000 toward the pursuit of higher education. Working in teams of three to five, participants are required to solve an open-ended, applied math-modeling problem focused on a realistic issue in 14 hours. For instance, this past year's problem focused on ways to improve the Census count, and last year's question asked if the Stimulus Act would improve the U.S. economy. This sort of real-world focus introduces applied math to students as a powerful problem-solving tool, and potentially, as a viable and exciting profession.

Judging of submissions is done in a three stage process by professional and PhD level applied mathematicians. For the first time in 2011, teams will receive individualized comments from first round judges about their paper's stregnths and weaknesses - to further enhance the educational benefit. (Received September 21, 2010)

1067-97-1557 **Virginia L Keen*** (keenvirl@notes.udayton.edu), 300 College Park Dr, Dayton, OH 45469-2316. *Connecting Mathematics Learning with Teaching.*

As a way to connect preservice early childhood teachers' and intervention specialists' learning of meaningful mathematics to their future teaching, a partnership was developed between the students in mathematics courses designed for PreK - grade 8 mathematics preservice teachers and children in local PreK-8 schools. Assignments for preservice teachers that supply evidence of their understanding of mathematics were created to include experience with urban first and second graders. Preservice teachers are paired with children and asked to write two letters that include mathematical questions for the children to investigate with their classmates and family members. Then, each preservice teacher creates a mathematically rich children's book for their "pen pal". Students are to write books with accompanying notes to the reader, grounding the book in theory and connecting it to state standards. This session includes an explanation of the communication between the preservice teachers and the school children, a description of the assignments, examples of the books and notes created, and a discussion of the benefits of the project for the college students as well as for the children and teachers in the local schools. (Received September 21, 2010)

1067-97-1571 **Dave Barker-Plummer*** (dbp@stanford.edu), CSLI, 210 Panama Street, Stanford University, Stanford, CA 94305. *Technology in Logic Education: Courseware, Automated Assessment and Data Mining.*

For the past twenty-five years, our project has been producing high-quality courseware for teaching the undergraduate logic curriculum. These courseware packages consist of textbooks, desktop applications and an Internet-based assessment service which acts as an always-available teaching assistant for students. Our applications provide learning environments allowing students to explore truth-tables, proofs, first-order and modal structures, and notions of heterogeneous reasoning. Our courseware is used in more than twenty-five countries at approximately four hundred institutions including high schools, community colleges, state and highly selective private universities.

In this talk I will describe the courseware packages that we have developed and demonstrate several of our applications, including a couple that not yet published, and indicate ways in which our courseware may be used in the undergraduate logic curriculum.

As a result of our Internet-based assessment service we have a large corpus of student work (containing in excess of 1.8 million items) produced while learning introductory logic. I will briefly describe preliminary work data mining this corpus for insights into student learning trajectories. (Received September 21, 2010)

1067-97-1580 **Deborah E. Seacrest*** (debbie.seacrest@gmail.com), 118 Henzlik Hall, University of Nebraska-Lincoln, Lincoln, NE 68588-0355. *What Can Students Learn from the Dice Game Hog?* Preliminary report.

In the game of Hog, two or more players take turns rolling dice. They may use as many dice as they wish, but if any of the dice show a one, the player's score for the round is zero. Otherwise, the score is the sum of the numbers on the dice. Typically, play continues until a player reaches 100 points.

I used this game with two groups of fourth through sixth grade students. One group was paying to participate in a summer program and the other was a free program for abused and neglected children. I observed the students' strategies and reactions to the game and noted significant differences between the two groups. The students all appeared to learn from the game, but they focused on and learned different topics due to differences in their prior knowledge and experiences. Some children focused on probability and how to maximize one's score, demonstrating some interesting ideas and misconceptions. Others spent their time finding better strategies for adding more than two numbers. Because students learned a variety of skills, this game may be particularly appropriate for an academically diverse classroom. (Received September 21, 2010)

1067-97-1592 **Rebecca H McGraw*** (rmcgraw@math.arizona.edu), 617 N Santa Rita Ave, Tucson, AZ 85716, and **Chantel Blackburn** (cblackburn@math.arizona.edu), 617 N Santa Rita Ave, Tucson, AZ 85716. *Teaching Mathematics to Future Teachers: Connecting Mathematics to Aspects of Teaching in University Courses.*

This session will report on a 3-year study of methods of teaching mathematics to future middle and high school teachers that focus on both mathematical knowledge development and the development of aspects of mathematics teacher practice. In this project, courses including Geometry, Mathematics Captstone, and History of Mathematics were co-taught by university mathematicians and mathematics educators. Perspectives from mathematics and from education were used to inform and enrich the courses. Although the focus of the courses was on the development of particular mathematics content, opportunities to make connection to students' future work as teachers were found throughout the courses. Teachers must select and create problems that assess particular ideas, analyze mathematical arguments, present and explain content, read mathematics, choose curricular materials, use various tools and technologies, and make sense of multiple ways of thinking about and solving problems. Examples of the integration of these aspects of teaching into university mathematics courses will be provided in this session. Presenters will also briefly describe ongoing research which examines the development and evolution of teaching collaborations across the mathematics and education communities. (Received September 21, 2010)

1067-97-1605 **Catherine Beneteau*** (cbenetea@cas.usf.edu), 4202 E. Fowler Ave, Tampa, FL 33620, and **Saad El-Zanati** (saad@ilstu.edu), Department of Mathematics, Illinois State University, Campus Box 4520, Normal, IL 61790. *Teaching Mathematics to Future Teachers: The Value of Co-Teaching Courses with Mathematics Educators.*

In this session, two university mathematicians will report on their experiences co-teaching mathematics courses, and methods of teaching courses, with mathematics teacher educators. Students in these courses were undergraduates pursuing degrees in mathematics with the intention of teaching middle or high school mathematics. The course co-taught were Geometry, Mathematics Capstone, and Methods of Teaching Mathematics. Co-teaching involved jointly planning all aspects of the courses, and sharing responsibility for teaching and grading. Significant challenges to co-teaching included increased time involved compared to teaching alone, differences in teacher practices across the two communities (mathematics and education), and the creation of classroom communities that integrated the perspectives of two instructors. Benefits to co-teaching included opportunities to reflect on teaching methods and develop new methods, the development of strategies for connecting mathematics and the teaching of mathematics in courses for future teachers, and the building of professional relationships and understandings across the communities of mathematics and education. (Received September 21, 2010)

1067-97-1622 **Patricia F Campbell*** (patc@umd.edu), Center for Mathematics Education, 2226 Benjamin Building, University of Maryland, College Park, MD 20742-1175. *Addressing Challenges in the Common Core: Mathematics Specialists in Elementary and Middle Schools.* Preliminary report.

The Common Core State Standards for Mathematics (CCSS) both reposition and refocus mathematics objectives in the K-8 curriculum, raising demands on teachers already challenged by calls to increase student achievement. Successful implementation of the CCSS will depend not only on assessment and curriculum development, but also on teachers' knowledge and instructional practice. Recently, mathematics specialists/coaches are being positioned in elementary and middle schools to serve as an on-site resource, addressing teachers' knowledge of mathematics content and pedagogy while catalyzing and sustaining teachers' efforts to define and implement meaningful instructional change across a school. This session will highlight some of the challenges raised by the content of the CCSS and report the results of a collaborative project that utilized a 3-year randomized control-treatment design to investigate the impact of knowledgeable mathematics specialists who served as coaches in elementary schools. Concluding remarks will consider (1) the feasibility of positioning specialists to address some of the demands raised by the CCSS and (2) the implications of mathematicians and mathematics educators working together to develop more rigorous and appropriate content courses for K-8 teachers. (Received September 21, 2010)

1067-97-1742 **W James Lewis*** (jlewis@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE. *The UNL Center for Science, Mathematics and Computer Education.* Preliminary report.

The mission of the University of Nebraska-Lincoln Center for Science, Mathematics & Computer Education is to support faculty engaged in educational activities focused on improving the teaching and learning of science, technology, engineering and mathematics (STEM) at both the K-12 and collegiate level. The Center has provided the foundation that has enable faculty to obtain resources, both internal to the university and external, including two NSF funded Math Science Partnerships, Math in the Middle and NebraskaMATH. We will discuss these programs and how the Center's support enables the development of successful projects. (Received September 21, 2010)

1067-97-1749 **W. James Lewis*** (jlewis@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68502. *The Mathematical Education of Teachers.* Preliminary report.

In 2001 the Conference Board of the Mathematical Sciences (CBMS) published The Mathematical Education of Teachers. Recently, CBMS has initiated a project to update the "MET". We will report on the impact of the MET over the past decade and provide a status report on the current initiative. (Received September 21, 2010)

1067-97-1768 **Rachel Cochran**, **Jason Fulmore**, **John C. Mayer** and **Bernadette Mullins*** (bmullins@bsc.edu). *Numerical Reasoning: An Inquiry-Based Course for K-8 Teachers.*

Numerical Reasoning is a course designed to help K-8 teachers and pre-service teachers develop a deeper understanding of operations on fractions, decimals, and percents and shift their teaching practice toward an inquiry-based approach. We describe challenging activities from the course and discuss teacher gains in content knowledge and changes in attitudes toward mathematics. We also report on changes in classroom instructional practice as measured by the Reformed Teaching Observation Protocol and gains in student achievement as measured by the Stanford Achievement Test. (Received September 21, 2010)

1067-97-1823 **Andrew G Bennett*** (bennett@math.ksu.edu), Department of Mathematics, Cardwell Hall, Kansas State University, Manhattan, KS 66506. *Quantitative Education as Applied Mathematics.*

When students work online, you automatically record large amounts of data about each student. The Center for Quantitative Education at Kansas State University has been applying data-mining techniques to this data to support our work in understanding how students learn and how to improve instruction in a technological environment. This has involved training graduate students working with the center in both mathematics education and techniques of applied mathematics. In this talk I will both discuss some of our results so far and how we have worked to integrate the Center fully into the life of the Mathematics Department. (Received September 21, 2010)

1067-97-1967 **Robert G Page*** (rpage@framingham.edu), Framingham State University, 100 State St., PO Box 9101, Framingham, MA 01701. *Teaching Mathematics in the Technological Classroom: Teachers Do, Technology Doesn't.* Preliminary report.

The variety of technological resources available to math teachers (at all levels, K and up) has never been greater, and many (if not the majority of) schools allocate a significant portion of their budget to the purchase and maintenance of technology. Thus, it is natural that schools encourage, pressure, or even require their faculty to make use of technology in the classroom. This fact is not lost on pre-service math teachers.

The natural question arises for the teacher educator: "How can one best prepare pre-service teachers to use technology in the mathematics classroom?" A common strategy is to instruct pre-service teachers on how to use specific technologies. This strategy has two flaws: there are too many different technologies to discuss, and specific technologies become obsolete over time. We propose a different answer to the question above, based on our experience with a professional development course for in-service secondary school teachers. The course was funded by a Massachusetts DOE Technology Enhancement Competitive grant and emphasized teaching mathematics using technology. (Received September 22, 2010)

1067-97-2139 **Corrine H Taylor*** (ctaylor1@wellesley.edu), 106 Central Street, Wellesley, MA 02482. *The Role of QL in the High School Mathematics Curriculum: What Students Need to Know to Be College Ready.*

High school teachers who have attended my professional development workshops on quantitative reasoning over the last four years have been surprised to learn what QR skills are expected of incoming first year college students

- surprised both by certain practical math topics that are fundamental in introductory economics and science courses yet are minimally presented or are absent from the typical high school math curriculum, and by topics that are universally present in high school math curricula but are rarely understood to a sufficient degree by entering college students. In this session I draw on my ten years of teaching QR at Wellesley College and on the experiences of the high school teachers who have taken my workshops and then subsequently infused a QR approach in their mathematics teachings. (Received September 22, 2010)

1067-97-2152 **Susanna S Epp*** (`sepp@depaul.edu`), Department of Mathematical Sciences, DePaul University, 2320 N. Kenmore Ave, Chicago, IL 60614. *The Role of Logic in the K-12 Mathematics Curriculum.*

How can we teach children important mathematical facts in ways that are both age-appropriate and intellectually honest? Some informal explanations are both helpful and suggestive of the mathematics that underlies the facts. Other explanations help students get right answers on tests but do not provide a sound basis for future understanding. This talk will examine examples of both kinds of explanations in the context of courses for prospective and in-service mathematics teachers. (Received September 22, 2010)

1067-97-2157 **Donald A Outing*** (`donald.outing@usma.edu`), Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996, and **Archie Wilmer**. *The Center for Leadership and Diversity in STEM (Science, Technology, Engineering, and Mathematics) at West Point.*

The Center for Leadership and Diversity in STEM (CLD_STEM) was established to increase the representation of underrepresented minorities in the fields of science, technology, engineering, and mathematics and to improve the mathematics education of underrepresented minority demographic groups (African American/black, Hispanic, American Indian/Alaska Native, and women) whose populations have historically experienced difficulty gaining access to various academic disciplines, and continue to be underrepresented in those fields. The Center enhances the Department of Mathematical Sciences' commitment to playing a national role in the challenge to reform and enrich mathematics programs while leveraging the Science, Technology, and Engineering intellectual resources of the West Point.

In this presentation, we will discuss CLD_STEM's mission, goals, outreach initiatives, and programs. (Received September 22, 2010)

1067-97-2158 **Stewart W Hengeveld*** (`hengeveldsl@mail.montclair.edu`), 27 Mountain Road, Wayne, NJ 07470. *Integrating Graduate Research into the Middle School Class Room.* Preliminary report.

In this talk, I will present a project that was designed to integrate graduate level research into middle school classrooms. The project starts with an early secondary level problem involving money and banking. Briefly, the problem deals with dollar bill distribution in certain ways. Solving the problem uses simple methods of counting, basic arithmetic, discrete math ideas, and some graphic techniques. Students involved in the project will have the opportunities to attempt to solve the problem by hands-on activities and mathematics manipulations assisted by the teacher and the graduate fellows. After students have thoroughly understood the problem and explored simple ways to find solutions, the graduate fellows will show students how to apply advanced algebraic techniques and algorithms to solve the problem. This illustrates and emphasizes the need and usefulness of mathematics beyond the classroom. It is expected that through activities like this, students raise the level of their mathematics skills, critical thinking, logical reasoning, and appreciation of mathematics. This project was developed with the support of the GK-12 grant under the NSF at Montclair State University (NSF Award #0638708). (Received September 22, 2010)

1067-97-2162 **Susanna S Epp*** (`sepp@depaul.edu`), Department of Mathematical Sciences, DePaul University, 2320 N. Kenmore Ave, Chicago, IL 60614. *Seemingly Abstruse Logical Principles Have Practical Importance.*

Logic, especially the logical principles governing quantified statements, is both essential to and ubiquitous in mathematical proof. This talk will analyze examples of common incorrect proofs given by university students, focusing on (1) the use of bound variables as if they continue to exist beyond the statements in which they are quantified, (2) the implicit use of existential instantiation, (3) the "dependence rule" for existential instantiation, and (4) universal instantiation and its use with existential instantiation. Suggestions for responding to student errors will be offered. (Received September 22, 2010)

1067-97-2203 **Joan Ferrini-Mundy*** (jferrini@msu.edu). *Mathematics, Educational Research, and STEM Education Policy: Challenges and Opportunities in the Intersection.*

Drawing on examples from my own experience, I will reflect on how making mathematics more central in educational research and in STEM education policy could improve endeavors in both arenas. I will describe a large-scale, multi-district K-12 mathematics and science education research and development project – Promoting Rigorous Outcomes in Mathematics and Science Education (PROM/SE) – where the project team confronted issues of curriculum coherence in mathematics. Using current national context and initiatives as examples, I will propose ways in which mathematics education research might better inform STEM education policy development and implementation. Specifically, the relationship of educational research to improvement in K-12 STEM education, undergraduate education, standards, assessments, and STEM education policy will be explored. (Received September 22, 2010)

1067-97-2365 **Brooke E Evans*** (bevans21@mscd.edu), 5121 W 101st Cir, Westminster, CO 80031, and **Patricia McKenna** (mckennap@mscd.edu), 712 Elliot St., Longmont, CO 80501. *An Electronic Classroom Model for Mathematics Content Courses.*

This session will discuss Metro's Math for Rural Schools Program, which offers teachers an opportunity to take college-level mathematics content courses online. The courses model teaching practices, which support development of mathematical proficiency and foster a mathematical community among teacher-learners. The course begins with a kick-off, face-to-face meeting where all of the teacher groups come together to discuss the course and begin problem-solving in order to establish classroom norms and become familiar with the technology. These face-to-face interactions are essential components of the course, which will be discussed in more detail at the session. The presentations are done via voice, electronic whiteboard, instant messaging, and webcam. We have found this method of delivery to be very effective and believe it to be a good model for effective, high-quality teacher professional development via an electronic classroom learning experience. (Received September 22, 2010)

1067-97-2385 **Cathy L Seeley*** (cseeley@austin.utexas.edu), 4907 Placid Pl, Austin, TX 78731. *Quantitative Literacy and College Readiness.*

Quantitative literacy is critical, but nearly non-existent in the typical high school program. With the wide acceptance of the recently published Common Core State Standards, there are new reasons to look at our high school mathematics offerings from a fresh perspective, especially the mathematics that might follow the three years of the high school 'Common Core.' The increasing expectation for all students to study mathematics every year in high school provides an opportunity to consider what additional mathematics content might best serve all students, regardless of their future path. We will look at how to incorporate statistics, discrete mathematics, finance, and other mathematics topics, as well as examining pedagogical approaches that help students develop critical college readiness skills and increasingly develop responsibility for their own learning. A recently developed 'fourth-year' mathematics course will be discussed as an example of a new generation of capstone mathematics courses for high school students that can engage them in rigorous, yet accessible mathematical tasks. (Received September 23, 2010)

1067-97-2398 **Juan J Arellano*** (juan.arellano@tamiu.edu), 1220 E. Fremont #8, Laredo, TX 78040. *A Rigorous Reconstruction of Some Concepts in Elementary Algebra for Avoiding Misconceptions.* Preliminary report.

It is common for a mathematics learner make mistakes when working with mathematics. Many of these mistakes could be as of a result of a misconception. Even though there exists research in pedagogy to address student misconceptions, there is a lack of research that address misconceptions mathematically. In the article "Problems with Rational Exponents in Elementary Mathematics" by Terutake Abe and Firooz Khosraviyani, the concept and definitions of the common power notation used in elementary mathematics are discussed with a focus on formalizing an introductory definition and avoiding misconceptions by students and teachers alike. Similarly, a target misconception from G. Donald's article "Misconceptions in Mathematics" will be analyzed and its corresponding concepts rigorously reconstructed with the purpose of avoiding misconceptions. (Received September 23, 2010)

1067-97-2400 **Imre Tuba*** (ituba@mail.sdsu.edu), San Diego State University, Imperial Valley, 720 Heber Ave, Calexico, CA 92231, and **Jeff Burt** (jeffdburt@gmail.com), San Diego State University, Imperial Valley, 720 Heber Ave, Calexico, CA 92231. *Aligning middle and high school teachers' teaching to new algebra trends in California.* Preliminary report.

STRIVE is a professional development project for middle and high school teachers based at San Diego State U, Imperial Valley. Imperial County is a high-poverty agricultural area east of San Diego with an 85% Hispanic population. The county reliably ranks last among California's 58 counties in math achievement. Schools allay a chronic need for math teachers by hiring teachers who obtained their qualifications via alternate methods. Meanwhile, California is moving toward more emphasis on and early introduction of algebraic principles in its K-12 curriculum.

STRIVE trains beginner math teachers–most of whom have no math degrees or credentials–so they can survive and establish work conditions that make them want to stay in their jobs. We run a summer institute aligned with practice teaching, and academic-year workshops. We mostly focus on algebra with intuitive and rigorous reasoning to help teachers adjust to new trends in the curriculum. We have raised the teachers' pedagogical math content knowledge in measurable ways. We have observed this knowledge trickle down to the students, who are also engaging in mathematical reasoning and finding flaws in each others' arguments.

We will discuss how we achieved some of these successes and some of the challenges along the way. (Received September 23, 2010)

Table of Contents for MAA Abstracts of Invited Addresses, SIGMAA Guest Lecturers, Presentations by Teaching Award Winners, and Session Papers

The presenter of each talk is indicated by an asterisk (*) in the abstract.

MAA ABSTRACTS

MAA Invited Addresses, SIGMAA Guest Lectures, and Presentations by Teaching Award Winners

1067-A0-34 **Steve Abbott***, Middlebury College, Middlebury, VT 05753. *Turning theorems into plays.*
The critical success of Tom Stoppard's *Arcadia* in the early 1990s fundamentally altered the perception that mathematics represented an off-putting and off-limits part of the intellectual spectrum for artists interested in writing for a popular audience. Since *Arcadia*, we have witnessed the emergence of a host of successful plays that deal with mathematics and mathematicians in thoughtful and creative ways. Some of the most well-known examples include *Proof*, by David Auburn, winner of the Pulitzer Prize in 2000, and *Copenhagen*, by Michael Frayn, which won the 2001 Tony Award for best play. Beyond these highly celebrated scripts, one can find a rich array of plays that are perhaps even more authentically mathematical. Set at a (mostly) fictional mathematics conference on the bitter English coastline in the winter of 1911, *The Five Hysterical Girls Theorem*, by Rinne Groff is a dark comedy about love, genius, aging and priority. In *Lovesong of the Electric Bear*, Snoo Wilson offers a fanciful, post-modern portrait of the tragic life of Alan Turing. Most recently, *A Disappearing Number* won the 2008 Olivier Award for Best Play for its dramatization of the fascinating relationship between Hardy and Ramanujan. We will take a first hand look at some of these scripts and explore the complementary ways in which mathematicians and artists carry out their respective searches for truth. (Received June 10, 2010)

1067-A0-35 **Robert M. Bell***, AT&T Labs, Florham Park, NJ. *Lessons from the Netflix Prize.*
In October 2006, the DVD rental company Netflix released more than 100 million user ratings of movies for a competition to predict new ratings based on prior ratings. The size of the data (over 17,000 movies and 480,000 users) and the nature of human-movie interactions produced many modeling challenges. One allure to data analysts around the world was a $1,000,000 prize for a team achieving a ten percent reduction in root mean squared prediction error relative to Netflix's existing algorithm. Besides producing a photo finish worthy of a movie, the 33-month competition spurred numerous advances in the science of recommender systems and machine learning, more generally. After describing some of the techniques used by the leaders, I will offer lessons and raise some questions about building massive prediction models; the role of statistics, computer science, and mathematics in such endeavors; and prizes as a way to advance science. This is joint work with Chris Volinsky and Yehuda Koren, current and former colleagues at AT&T Labs-Research. (Received June 10, 2010)

1067-A0-36 **David M. Bressoud***, Macalester College, Math & Computer Science Dept., 1600 Grand Ave., St. Paul, MN 55105. *Issues of the transition to college mathematics.*
Over the past quarter century, college enrollments at the level of calculus and above as well as the number of mathematics majors have remained flat or decreased slightly. This is despite the fact that the US population has increased by 25% and total college enrollments have gone up by almost 50%. This lack of growth in mathematics impacts not just math departments but all science, engineering, and other mathematically intensive majors. This talk will examine the factors that may be impeding growth and describe promising practices. (Received June 10, 2010)

1067-A0-38 **Yuval Peres***, Microsoft Research, 1 Microsoft Way, Redmond, WA 98052. *Laplacian growth and the mystery of the abelian sandpile: A visual tour.*
We compare several growth models on the two dimensional lattice. In several models, like internal DLA, rotor-router aggregation and competitive erosion, the scaling limits are universal; in particular, starting from a point source yields a disk.

In the abelian sandpile, particles are added at the origin and whenever a site has four particles or more, the top four particles topple, with one going to each neighbor. Despite similarities to other models, for the sandpile, the intriguing pattern that arises is not circular and depends on the particular lattice- this contrasts with related growth models, like internal diffusion limited aggregation. It is an open problem to prove a scaling limit exists for the sandpile, though some bounds are known. This research has been greatly influenced by pictures of the relevant sets, which I will show in the talk. They suggest a connection to conformal mapping, which has not been established yet.

This talk is based on joint works with Lionel Levine, Anne Fey and Jim Propp. (Received June 10, 2010)

1067-A0-39 **Edward R. Scheinerman***, Johns Hopkins University, Shaffer Hall, 3400 N. Charles St., Baltimore, MD. *On the intersection of graphs and geometry.*

Graphs are combinatorial structures (finite sets of vertices and pairs of vertices we call edges) and yet we often think of them in geometric terms (vertices as points, edges are curves). In this talk we explore geometric representations of graphs in which vertices correspond to geometric objects (line segments, disks, curves, and so on) and edges correspond to interaction between the objects (typically, nonempty intersection). (Received June 10, 2010)

1067-A0-40 **Katherine Socha***, Saint Mary's College of Maryland, Dept. of Math and Computer Science, 18592 E. Fisher Rd., St. Mary's City, MD 20686. *Sea battles, Benjamin Franklin's oil lamp, and jellybellies.*

"During our passage to Madeira, the weather being warm, and the cabin windows constantly open for the benefit of the air, the candles at night flared and run very much, which was an inconvenience. At Madeira we got oil to burn, and with a common glass tumbler or beaker, slung in wire, and suspended to the cieling of the cabbin, and a little wire hoop for the wick, furnish'd with corks to float on the oil, I made an Italian lamp, that gave us very good light. . . " (Benjamin Franklin, December 1, 1762, letter to John Pringle).

Observations of real phenomena have led to mathematical modeling of surface water waves, interfacial waves, and Lagrangian coherent structures, among other examples. This expository talk will provide a quick tour of the (mostly advanced undergraduate level) mathematics needed to describe idealized versions of the rings formed by striking a surface of water with a large object (like a bomb), the oil-water waves observed by Founding Father Benjamin Franklin on his voyage to Madeira, and the motion of nutrient-laden water being swept into the underbelly of swimming jellyfish. (Received June 10, 2010)

1067-A0-41 **Melanie Matchett Wood***, American Institute of Mathematics; and Stanford University, Dept. of Math, Sloan Hall, Stanford, CA 94305. *Binary quadratic forms: From Gauss to algebraic geometry.*

Gauss's composition law on binary quadratic forms with integral coefficients is one of the gems of number theory that has been leading to new mathematics for over 200 years. We will see how these simple quadratic polynomials of two variables can be themselves multiplied via a group law discovered by Lagrange, Legendre, and Gauss before there was a concept of an abstract group. These quadratic forms are linked to unique factorization and its failure in most rings of numbers larger than the integers. We will further explore what happens when the coefficients of the polynomials are allowed to be from rings larger than the integers and how we are led to new kinds of binary quadratic forms, eventually taking their coefficients in rings of functions on geometric spaces and telling us about the geometry of those spaces. (Received June 10, 2010)

1067-A0-127 **Tony DeRose***, Pixar Animation Studios. *How mathematics is changing hollywood.*

Film making is undergoing a digital revolution brought on by advances in areas such as computer technology, computational physics, and math. Using numerous examples drawn from Pixar's films, this talk will provide a behind the scenes look at the role that mathematics plays in the revolution. (Received July 26, 2010)

1067-A0-355 **Joe Albree***, Dept of Mathematics, Auburn Univeristy Montgomery, Montgomery, AL 36124-4023. *Bridges of Trigonometry in the Anglo-American Colonies and the United States.* Preliminary report.

In the "howling wilderness" (as Edward Hogan [Hogan 1974] characterized the 17th century Anglo-American colonies), plane trigonometry was considered higher mathematics. Contrasts between the higher mathematical landscape in these colonies and that of the mother country, especially with regard to plane trigonometry, narrowed somewhat during the 18th century. We trace the development of plane trigonometry in the United States up to the early decades of the 19th century, by which time it had come to closely resemble that which we teach today. The term "Bridges" has at least two senses for us: (i) those plane trigonometric facts and practices brought from England to the colonies and the United States; and (ii) a Platonic summary. (Received August 26, 2010)

1067-A0-578 **Zvezdelina Stankova***, Mills College. *What comes from within. . . when life serves you lemons.*

No, there is no mistake: a deliberate pun, the title is a hybrid between a wisecracker by a most famous American writer and the dramatic math story of a 5th grade girl. As the epilogue in the book "A Decade of the Berkeley Math Circle—the American Experience", vol. I, (publ. AMS/MSRI, 2009) retells: *There is more than one way to fall in love with mathematics. Many Eastern European mathematicians have come along the path of math circles, where they have learned for the first time that the world of math is larger than one could imagine, more interesting, and more diverse. The math circle culture is ingrained in the societies in these countries.*

During the communist era, established mathematicians and pre-college teachers considered it their duty to expose the younger generation to the wonders of mathematics. And so they teamed together to found and run math circles. . . " for over a century. The idea of math circles was carried over to the U.S. about 15 years ago mainly by immigrants, yet it was implemented on the U.S. soil with the help and enthusiasm of U.S.-grown mathematicians and educators. Has the young but already strong and contagious U.S. math circle movement had any impact on the battered pre-college educational landscape of the U.S.? Has it had any effect on preparing the U.S. best minds for their future role as mathematics, science, and technology leaders? To answer these questions is much related to deciphering the meaning of the present title, which this talk aims to do. (Received September 10, 2010)

1067-A0-965 **Erica Flapan*** (eflapan@pomona.edu), 610 N. College Ave., Pomona College, Department of Mathematics, Claremont, CA 91711. *The problem of how to be a good teacher is undecidable.* Preliminary report.

I spent much of my early career trying to find the algorithm for how to be a good teacher. I read articles about pedagogical techniques and talked to successful teachers about their methods. But nothing seemed to work quite as well for me as it did for the person describing it. Then I began to compare being a good teacher with being a good parent. I had never sought an algorithm for good parenting, so why should I expect there to be one for good teaching. In fact, there is no teaching technique that will work at all institutions, for all teachers, all classes, and all students. Rather, each person's teaching methods should fit their personality and their mathematical preferences as well as the needs and goals of their courses and their students. In this talk I will describe some pedagogical techniques that have worked for me and others that have not. (Received September 17, 2010)

1067-A0-1172 **Keith Devlin*** (devlin@stanford.edu), Cordura Hall, 210 Panama Street, Stanford, CA 94305-4115. *Will the real philosophy of mathematics please stand up.* Preliminary report.

The Philosophy of Mathematics is a fascinating and well-established area of scholastic activity with a long history. Yet it has virtually nothing to say about mathematics as practiced by the majority of individuals who do mathematics on a regular basis, nor of the layperson's understanding of what mathematics is. There's nothing wrong in that, but it does mean the discipline's name does not accurately reflect the meanings of its constituent words, putting it in the same category as "World Series" or "Miss Universe." What would a "philosophy of mathematics" look like in order to fully justify that title? (Received September 19, 2010)

1067-A0-2432 **Lisa Fauci***, Department of Mathematics, Tulane University, New Orleans, 70118. *The biofluiddynamics of swimming and pumping: Recent insights.*

In many biological processes, elastic boundaries move through a fluid or move the fluid itself. These elastic boundaries may be passive or actuated, and may interact with a Newtonian fluid or one that exhibits more complex constitutive properties. In this talk, I will discuss successes and challenges in modeling swimming of flagellated microorganisms, pumping and mixing of complex fluids, and an integrative model of lamprey locomotion. (Received September 22, 2010)

The Rebirth of Special Functions

1067-AA-992 **Peter D. Miller*** (millerpd@umich.edu), Dept. of Mathematics, University of Michigan, East Hall, 530 Church St., Ann Arbor, MI 48109. *Special Functions and Universal Behavior in Integrable Systems.*

An integrable system is a mathematical problem that can be analyzed with great precision because some hidden structure is present, making the problem rather unexpectedly tractable. The most famous examples include the initial-value problems for the Korteweg-de Vries and nonlinear Schrödinger equations, nonlinear partial differential equations governing many interesting physical processes. In recent years it has been understood, using the full power of integrability, that in certain natural asymptotic limits the solutions of these (and other) equations behave in a universal way that is independent of the initial conditions. The universal behavior that appears is in every case given in terms of special function. This talk will be an introductory survey of some of these new results designed for an undergraduate audience. (Received September 17, 2010)

1067-AA-1292 **Amanda Folsom*** (amanda.folsom@yale.edu), Yale University, Mathematics Department, P.O. Box 208283, New Haven, CT 06520-8283. *Special functions and modular forms in number theory.*

In this talk we will emphasize the interplay and relationships between special functions and modular forms in number theory. Modular forms, which, loosely speaking, are complex analytic functions equipped with certain symmetries, have been central to many notable problems, including Fermat's Last Theorem, and the Riemann Hypothesis. Historically, there are many famous examples relating modular forms to basic hypergeometric series (or q-hypergeometric series), which are particular special functions, however the precise interplay between the two remains a mystery. Special functions also appear in formulas describing the Fourier coefficients of modular forms, which are intrinsically rich with information. Designed for an undergraduate audience, this talk will introduce these aspects of special functions, noting new developments in the area of "mock modular forms", and fundamental applications to the theory of integer partitions, both old and new. (Received September 20, 2010)

1067-AA-1306 **Veronika Pillwein*** (vpillwei@risc.jku.at), Joh. Kepler University, Altenbergerstr. 69, 4040 Linz, Austria. *Special Functions and High Order Finite Element Methods.*

High order finite element methods are a widely used tool to solve systems of partial differential equations numerically. Starting from the variational formulation of a system, the approximate solution is sought as an expansion in terms of polynomial basis functions that are often built as combinations of orthogonal polynomials. In the design and analysis of these basis functions several properties of orthogonal polynomials are exploited, many of which can be proved and discovered using symbolic algorithms. In this talk, we will survey some of the recent results we obtained in this area. (Received September 20, 2010)

1067-AA-1665 **Mark W. Coffey*** (mcoffey@mines.edu), 16th and Illinois Streets, Department of Physics, Colorado School of Mines, Golden, CO 80401. *Special functions, mathematical physics, and number theory.*

Special functions and numbers occur in many areas of mathematical physics, including random matrix theory, calculations of quantum field theory and quantum mechanics, and diverse areas of classical theoretical physics. Often the special functions have exact known values in terms of important special numbers. For instance, the Riemann zeta function at even integers evaluates in terms of Bernoulli numbers, and the digamma function at the integers gives the Euler constant and harmonic numbers. We will illustrate the use of special function theory in a context of theoretical high energy physics that leads to connections with number theory. (Received September 21, 2010)

1067-AA-1927 **Luis A Medina*** (luis.medina@uprrp.edu), Department of Mathematics, University of Puerto Rico, Box 70377, San Juan, PR 00936. *Special Functions and Computer Algebra.*

We all know how powerful computers are as number crunchers. Nowadays, however, computer also do a great job as symbol-crunchers. Roughly speaking, computer algebra is the field of mathematics and computer science where computation is performed on symbols rather than on numeric values. The importance of special functions on many algorithms related to computer algebra is undeniable. In this talk, we discuss the relation of special functions and computer algebra. The talk is intended for an undergraduate audience. (Received September 22, 2010)

1067-AA-2279 **Lipika Deka*** (ldeka@csumb.edu), 100 Campus Center, Department of Mathematics and Statistics, Chapman Science Bldg, Seaside, CA 93955. *Special Functions in Combinatorics.*

Combinatorics and Special Functions were two unrelated subjects for a long time. With the fascinating developments in Combinatorics starting in the early twentieth century, many mathematicians started noticing Special Functions in their solutions to some of the most important combinatorial problems. One relation between these two subjects appeared in Enumerative Combinatorics. Some of the connections are the famous Rogers-Ramanujan identities and other identities for partition of integers. This talk will discuss some of these famous results in Enumerative Combinatorics and show how these are related to some of the Special functions. (Received September 22, 2010)

Laplacian Growth: Visual Mathematics

1067-AB-1370 **Janko Gravner*** (gravner@math.ucdavis.edu), Mathematics Department, University of California, Davis, CA 95616. *Digital Snowflakes.*

This talk will be on joint work with David Griffeath on diffusion-based models of snow crystal growth. To this day, the growth of snow crystals, often called snowflakes, with its tension between disorder and pattern formation, remains puzzling in many respects. With emphasis on computer-generated pictures and movies, the talk will review a few mathematical models of snow crystal dynamics, and discuss their contributions to mathematics and to understanding of real snowflakes. (Received September 20, 2010)

1067-AB-1446 **Alexander E Holroyd*** (holroyd@microsoft.com). *Random Sorting.*
See http://research.microsoft.com/ holroyd/sort/ for pictures.

Sorting a list of items is among the most celebrated of algorithmic problems. If one must do this by swapping neighboring pairs, the worst initial condition is when the n items are in reverse order, in which case n choose 2 swaps are needed. A sorting network is any sequence of n choose 2 swaps which achieves this.

This seemingly simple concept reveals amazing new structure when an element of randomness in introduced. Specifically, choose an n-item sorting network uniformly at random. It is conjectured that, in limit n -> infinity, the trajectories of individual items are random Sine curves, while the half-time permutation matrix concentrates in a cricular disc. These conjectures are overwhelmingly supported by simulation evidence, consistent (but weaker) rigorous results, and an extremely plausible geometric picture. I will explain all this with the help of visual demonstrations. No prior knowledge will be assumed.

Based on joint works with O. Angel, V. Gorin, D. Romik, and B. Vira (Received September 21, 2010)

1067-AB-1770 **David Perkinson*** (davidp@reed.edu), 3203 Woodstock Blvd., Portland, OR 97202.
Sandpiles, domino tilings, and Chebyshev polynomials. Preliminary report.

Symmetric recurrent sandpile configurations on a grid graph are related to domino tilings of grids and Möbius strips. The presentation will feature open-source, free software for sandpile computations and visualization. (Received September 21, 2010)

1067-AB-2012 **Tobias Friedrich***, Max-Planck-Institut für Informatik, Campus E1.4, 66123 Saarbrücken, Germany. *Fast Simulation of Large-Scale Growth Models.*

Growth models like the rotor-router model or internal diffusion-limited aggregation (IDLA) contain very surprising and mathematically not well understood structures. Many of these structures only become evident if sufficiently many particles are involved. Unfortunately, traditional step-by-step simulation requires a runtime quadratic in the number of particles. Based on a "least action principle" we present an algorithm which computes the final state of several growth models without computing all intermediate states. Starting from an educated guess for the so-called odometer, we successively correct under- and overestimates and provably arrive at the correct final state. For the rotor-router model this gives a close-to-linear runtime behavior and allows simulations of up to ten billion particles. (Received September 22, 2010)

1067-AB-2120 **James G. Propp***, One University Avenue, Lowell, MA 01854. *Self-organizing structures in rotor-router blobs.*

Rotor-router aggregation is a deterministic discrete version of Laplacian growth. Blobs grown in the square lattice using rotor-router dynamics are remarkably close to being circular. Also, rotor-router growth gives rise to beautiful pictures that exhibit unexplained symmetries involving the map $z \mapsto 1/z^2$ of the unit disk to its complement in the complex plane. In some cases, there are salient and stunning visual effects that defy immediate translation into mathematical assertions, conjectural or otherwise. (Received September 22, 2010)

1067-AB-2198 **Matthew Cook***, Institute of Neuroinformatics, 190 Winterthurerstrasse, CH-8057 Zurich, Switzerland. *On the Roundness of Rotor Router Blobs.*

The "Rotor Router" model is an extremely simple rule found by Jim Propp, in which each grid location absorbs the first particle to arrive and thereafter routes arriving particles to one of its four neighbors in a clockwise repetitive sequence. If we inject many particles at the origin, each particle (after the first) gets routed around until it arrives at an unvisited site where it gets absorbed. Surprisingly, the resulting area of absorbed particles is nearly a perfect circle, a phenomenon for which we have neither a proof nor even any clear heuristic reasoning, despite the simplicity of the process that creates the shape. We will present some experimental results showing that this shape is within a third of a pixel of being a perfect circle, and that even the slight remaining irregularities follow a clear pattern. We will also present some conjectures regarding the shapes and rotor patterns produced by this process, including one regarding the convexity of the shape, which leads to a surprising application of Pick's theorem. (Received September 22, 2010)

The Beauty and Power of Number Theory

1067-AC-297 **Jeffrey C Lagarias*** (lagarias@umich.edu), Dept. of Mathematics, Univ. of Michigan, 530 Church Street, Ann Arbor, MI 48109-1043. *The Takagi function.*

Teiji Takagi (1875-1960) is well known in number theory for his important work in class field theory. He studied at Berlin, then at Goettingen with David Hilbert, and completed his degree in Japan in 1903. He had many interests, and wrote an early paper constructing a continuous nondifferentiable function on the unit interval, now called the Takagi function. We will discuss properties of this function, which has a fractal appearance. These properties involve number theory and probability theory. (Received August 17, 2010)

1067-AC-531 **Van H. Vu** and **Melanie Matchett Wood*** (mwood@math.stanford.edu), Stanford University, Dept of Mathematics, Building 380, Stanford, CA 94305, and **Philip Matchett Wood**. *Using finite fields to prove things about the complex numbers.*

We show how number theory can help us to map complex numbers to finite fields, preserving specified algebraic incidences, even though there is no such ring homomorphism. This allows us to transfer results that can be proven over finite fields to the complex numbers, and we give applications in arithmetic combinatorics, such as sum-product estimates and the probability that a random matrix is singular. (Received September 08, 2010)

1067-AC-1058 **H. M. Stark***, Department of Mathematics - 0112, UCSD, 9500 Gilman Drive, La Jolla, CA 92093. *Landau's Class Number Theorem: A Gem That Wasn't.* Preliminary report.

In the 1930's, Heilbronn proved the Gauss conjecture that there are only a finite number of complex quadratic fields with a given class-number. In the papers that followed in rapid succession, the culminating result was a theorem of Siegel which has never been improved. However, in 1918, Landau published two remarkable papers in which all the key ingredients of Siegel's theorem appear. (Received September 17, 2010)

1067-AC-1067 **Krishnaswami Alladi*** (alladik@ufl.edu), Department of Mathematics, Gainesville, FL 32611. *Euler's pentagonal numbers theorem, companions and variations.*

Euler's celebrated Pentagonal Numbers Theorem is one of the most fundamental in the theory of partitions and q-hypergeometric series. From this Euler deduced an important recurrence relation for the partition function. This recurrence was what MacMahon used to construct a table of partitions in order to verify the famous Hardy-Ramanujan asymptotic formula for the partition function. And it was on seeing MacMahon's table of values that Ramanujan wrote down his spectacular congruences for the partition function. Another fundamental development was Jacobi's triple product identity for theta functions which may be viewed as a generalization of the pentagonal numbers theorem. After discussing these major developments emerging from the pentagonal numbers theorem, we will describe some new companions to, and variations of, the pentagonal numbers theorem. These include some elegant results discovered by Nathan Fine in the 1950s and some new partition theorems due to author that are deduced from partial theta identities of Ramanujan and Andrews. (Received September 17, 2010)

Topics in Hopf Algebras

1067-AD-405 **David A Jordan*** (djordan@math.mit.edu), Dept. of Mathematics, MIT, 77 Massachusetts Ave, Rm 2-236, Cambridge, MA 02130, and **Eric Larson**. *On the classification of fusion categories in small dimensions.*

Fusion categories are certain mild generalizations of finite groups, which retain the categorical features of finite group representations, while jettisoning the representations themselves. Just as studying finite groups helps us build intuition for more general constructions in representation theory, studying fusion categories helps us build intuition for higher categories, tensor categories, and their module categories: each of these notions become eminently calculable and concrete in the setting of fusion categories. As an illustration, we will discuss the classification of fusion categories in small dimensions, including joint work with Eric Larson. (Received September 01, 2010)

1067-AD-509 **Miriam Cohen*** (mia@cs.bgu.ac.il), Department of Mathematics, Ben Gurion University, Beer Sheva, Israel, and **Sara Westreich** (swestric@mail.biu.ac.il), Department of Managment, Bar Ilan University, Ramat Gan, Israel. *Hopf algebras- a unifying theory.* Preliminary report.

We shall start with group algebras kG, where G is a group and k is a field as the basic example of Hopf algebras. We shall discuss how Hopf algebras unify many other objects in mathematics and indicate its importance in Physics and even in computer science. (Received September 07, 2010)

1067-AD-1066 **Andrea Jedwab*** (jedwab@usc.edu), 3620 S Vermont Ave, KAP 464D, Los Angeles, CA 90089. *Frobenius-Schur indicators: from groups to Hopf algebras.*

The Frobenius-Schur indicator is a very useful invariant, first considered by Frobenius and Schur in the study of representations of finite groups. We will study the connection between the indicator and bilinear forms and see how its definition was extended from representations of groups to those of Hopf algebras. (Received September 17, 2010)

1067-AD-1185 **David E Radford*** (radford@uic.edu), Mathematics, Statistics, and Computer Sience, U. of Illinois at Chicago, 851 S. Morgan (m/c 249), Chicago, IL 69607-7045. *Knots and Algebra Intertwined.*

How to distinguish knots has been a subject of intense interest for many years. One approach is through invariants. Classical invariants are scalars or polynomials which do not depend on permissible topological moves to knots. There is an algorithm known as "bead sliding" for constructing knot invariants from some types of algebras and Hopf algebras. We will describe the algorithm, relate algebra and topology, and give some examples. (Received September 19, 2010)

1067-AD-1314 **Stefaan Caenepeel*** (scaenepe@vub.ac.be), Pleinlaan 2, B-1050 Brussels, Belgium. *Corings and descent theory.*

Corings are algebras (or monoids) in the opposite of the category of bimodules over a ring. We present several examples, and introduce the notion of grouplike element. A Galois coring is a coring with a grouplike element, such that a certain map, called the canonical map is bijective. The definition is motivated using descent theory, and can be used to provide an elementary reformulation of Galois descent theory and some of its generalizations. (Received September 21, 2010)

1067-AD-1696 **Miodrag Cristian Iovanov*** (yovanov@gmail.com), 3620 S Vermont Ave KAP108, Los Angeles, CA 90089. *Hopf Algebras from Graphs.* Preliminary report.

We investigate Hopf algebra structures that can be introduced on incidence and path coalgebras. This general problem is an open question of interest; we look at the particular case when the Hopf algebra is required to have a nonzero integral (the non-(co)comutative generalization of the algebra of functions on a compact group). Such a Hopf algebra is known to have the "co-Frobenius" property. We give the classification of co-Frobenius coalgebras which are subcoalgebras of full path (quiver) coalgebras but which have a basis of paths, show how some of these coalgebras are related to category theory and homological algebra, and determine Hopf algebra structures on these. (Received September 21, 2010)

Fish Tales: Stories from Mathematical Fluid Dynamics

1067-AE-1022 **Laura A Miller*** (lam9@email.unc.edu), CB 3250 Phillips Hall, Chapel Hill, NC 17178, and **Christina Hamlet** and **Arvind Santhanakrishnan**. *How jellyfish can inspire mathematics: A case study of the feeding currents generated by upside-down jellyfish.*

The jellyfish has been the subject of numerous mathematical and physical studies ranging from the discovery of reentry phenomenon in electrophysiology to the development of axisymmetric methods for solving fluid-structure interaction problems. In this presentation, we develop and test mathematical models describing the pulsing dynamics and the resulting fluid flow generated by the upside down jellyfish, Cassiopea. The kinematics of contraction and distributions of pulse frequencies were obtained from videos and used as inputs into numerical simulations. Particle image velocimetry was used to obtain spatially and temporally resolved flow fields experimentally. The immersed boundary method was then used to solve the fluid-structure interaction problem and explore how changes in morphology and pulsing dynamics alter the resulting fluid flow. Unlike pelagic (swimming) jellyfish, there is no evidence of the formation of a train of vortex rings. Instead, significant mixing occurs around and directly above the oral arms and secondary mouths. We found good agreement between the numerical simulations and experiments, suggesting that the presence of porous oral arms induce net horizontal flow towards the bell and mixing. (Received September 17, 2010)

1067-AE-1602 **Andrew J. Bernoff*** (ajb@hmc.edu), Department of Mathematics, Harvey Mudd College, 301 Platt Blvd., Claremont, CA 91711. *Langmuir Layers: Exploring a (nearly) Two-dimensional Fluid Experiment.*

A Langmuir Layer is a molecularly thin layer of a polymer, lipid or liquid crystal on the surface of another fluid. In this (nearly) two-dimensional layer, we can observe bubbles of a fluid phase that even when stretched or highly contorted always appear to return to a circular shape. The force driving these evolutions is line tension, a two-dimensional analog of surface tension. We report on a combined experimental, theoretical, and numerical study of Langmuir layers, and show how we can deduce the strength of the line tension in the system by comparing theory and experiment. As time permits we will also describe other phenomena observed in Langmuir systems, including collapse of gas phase bubbles, co-existence of three or more fluid phases, and formation of dogbone and labyrinth patterns due to dipolar repulsion in the layer. (Received September 21, 2010)

1067-AE-1672 **Rachel Levy*** (levy@hmc.edu), 301 Platt Blvd, Claremont, CA 91711, and **Students from DYNAR Research Group** (levy@hmc.edu), 301 Platt Blvd, Claremont, CA 91711. *An economical micro-submarine testbed for validation of 3D cooperative control strategies for underwater robots.*

Undergraduate students from the Dynamic Networks for Aquatic Robots (DYNAR) research group at Harvey Mudd College will describe a new aquatic robotic testbed designed to test algorithms for coordination and control of micro remote control submarines. The testbed is implemented with a three-dimensional tracking algorithm utilizing views from two planes. Results from experiments in the testbed will be compared with simulations of a mathematical model describing the motion of the submarines in response to propeller forces. (Received September 22, 2010)

1067-AE-2417 **Keith Mertens*** (mertens@email.unc.edu), Carolina Center for Interdiscip Applied Math, University of North Carolina, Chapel Hill, NC 27599. *Hydrodynamics and pattern formation.* Preliminary report.

Theoretical and experimental studies of problems in fluid dynamics relating to free surfaces and pattern formation. (Received September 23, 2010)

The Intersection of Graphs and Geometry

1067-AF-1469 **Donniell Fishkind*** (fishkind@ams.jhu.ed), Department of Applied Mathematics, Johns Hopkins University, Baltimore, MD 21218, and **Lowell Abrams** and **Carey Priebe**. *The Genus of a Digital Image is Determined by its Foreground, Background, and Reeb Graphs.*

The human cerebral cortex may be modeled as a topological sphere dividing the cranial cavity into two regions, interior and exterior. A magnetic resonance image of the brain provides a cubical complex (digital image) representing the interior, with boundary representing the cortex itself. Because the cortex is densely folded, such a representation of the cortex typically has many topological handles which are artifacts of noise and limited resolution. Shattuck and Leahy (D.W. Shattuck and R.M. Leahy, "Automated graph-based analysis and correction of cortical volume topology," devised an automated topology-correction algorithm to remove these artifacts to restore the spherical topology of the imaged cortex, and their approach was fundamentally based on their Spherical Homeomorphism Conjecture concerning the "foreground graph" and the "background graph," which are graphs that arise respectively from the cubical complex and its complement. Our main result, which implies the truth of their conjecture, shows that the topological genus of the boundary of a digital image is precisely half of the sum of the cycle ranks of the foreground graph, the background graph, and the image boundary's Reeb graph relative to the natural height function. (Received September 21, 2010)

1067-AF-1481 **R. Bruce Richter*** (brichter@uwaterloo.ca), Department of Combinatorics and Optimization, Faculty of Mathematics, University of Waterloo, Waterloo, ON N2L 3G1, Canada. *Kleitman's Parity Theorem for crossing numbers.*

Kleitman proved that the complete bipartite graph $K_{m,n}$ (both m and n odd) has the property that in any two (appropriate) drawings of it in the plane, the numbers of crossings have the same parity. He used this to evaluate the crossing number of $K_{m,n}$, whenever $m \leq 6$. His proof was sufficiently controversial that he published a second paper clarifying the proof.

His argument involves converting one drawing into the other by "sliding" the edges around and counting how much the crossing number changes as an edge slides over a vertex. In this talk, I will present a much more combinatorial proof that Dan McQuillan and I have found. (Received September 21, 2010)

1067-AF-1483 **Dan Archdeacon*** (dan.archdeacon@uvm.edu), Department of Mathematics and Statistics, University of Vermont, Burlington, VT 05405. *Geometric Drawings of Graphs Using Few Edge Lengths.* Preliminary report.

A geometric drawing of a graph represents the graph in the plane with all edges as straight line segments. These drawings come in two flavors: edges can cross, or they cannot. The latter flavor is called an embedding.

One measure of the niceness of a geometric drawing of a graph is the number of different edge-lengths used to represent its edges. Can every graph be represented (with crossings) using only integer-length edges? Does every planar graph have a subdivision that can be embedded using only unit-length edges? What is the fewest number of edge-lengths needed to represent (with crossings) the complete graph?

In this talk we survey these and other results in this area. Both flavors of drawings will be sampled. (Received September 21, 2010)

1067-AF-1532 **Christian A. Duncan*** (duncan@latech.edu), Computer Science Program, Louisiana Tech University, Ruston, LA 71272, and **David Eppstein**, **Michael T. Goodrich**, **Stephen G. Kobourov** and **Martin Nöllenburg**. *Lombardi drawings: an artist-inspired approach to drawing graphs.*

In this presentation, we introduce a form of representing graphs inspired by work from the late American abstract artist Mark Lombardi (1951–2000). In Lombardi drawings, edges are represented as circular arcs and are equally spaced around their adjacent vertices, yielding perfect angular resolution. This differs from other graph drawing paradigms such as straight-line plane grid drawings where edges are line segments that do not intersect other edges, vertices are placed on integer coordinates within some bounded grid area, and there is no restriction on the angular resolution.

This new variation opens up a realm of possibilities in producing aesthetically-pleasing drawings of graphs. Using techniques from graph theory, graph drawing, and geometry, we shall explore and illustrate some of the graphs that can and cannot be represented as Lombardi drawings including regular graphs, graphs of bounded degeneracy, and various families of planar graphs including trees. (Received September 21, 2010)

1067-AF-1534 **Ann N. Trenk*** (atrenk@wellesley.edu), Department of Mathematics, Wellesley College, Wellesley, MA 02481. *Tolerance Graphs.*

Interval graphs are important both because they arise in a variety of applications and also because some well-known optimization problems can be solved efficiently when restricted to this class of graphs. Tolerance graphs, a generalization of interval graphs, retain some of these desirable properties while encompassing a larger set of graphs.

A graph $G = (V, E)$ is a *tolerance graph* if each vertex $v \in V$ can be assigned a real interval I_v and a positive tolerance $t_v \in \mathbf{R}$ so that there is an edge between vertices x and y precisely when the length of the intersection of I_x and I_y meets or exceeds one of the tolerances t_x, t_y (that is, $xy \in E(G)$ iff $|I_x \cap I_y| \geq \min\{t_x, t_y\}$).

The nature of this definition means that many of the results about tolerance graphs involve geometric arguments. In this talk we give an overview of the work done in tolerance graphs. (Received September 21, 2010)

1067-AF-1536 **William T. Trotter*** (trotter@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *Interval Shadow Orders.*

Consider a family of line segments in the plane. There is a natural partial order $<$ defined on this family by setting $s < t$ when (1) s and t are disjoint, (2) the projection of s on the x–axis is contained in the projection of t on the x–axis, and (3) any vertical line intersecting both s and t intersects s below t. In more descriptive terms, $s < t$ when s is in the "shadow" of t.

Which partial orders are shadow orders? Can you recognize them with an efficient algorithm? These are surprisingly difficult questions. In this talk, we outline the origins of this problem, the motivation for asking questions of this type, and the connections with other related classes of graphs and orders.

This is joint work with Csaba Biró of the University of Louisville. (Received September 21, 2010)

1067-AF-1541 **Jerry Spinrad*** (spin@vuse.vanderbilt.edu), Electrical Engineering and Computer Science, School of Engineering, Vanderbilt University, Nashville, TN 37240, and **Garrett Linn**. *Precedence Orders.*

There are several well known general methods for defining graphs and partial orders based on relationships between geometric and other types of objects. For example, there is a great deal of work on classes based on intersection graphs, in which vertices of a graph are adjacent if the corresponding objects have nonempty intersection. Similarly, we have notions of containment orders (element x is less than or equal to element y if the object corresponding to x is contained in the object corresponding to y). Recently there has been work on defining graphs based on other relationships between objects; visibility graphs, tolerance graphs, and to a lesser extent overlap graphs have been studied for various objects.

We discuss the notion of precedence orders of objects; element x is less than or equal to element y if the object corresponding to x comes "before" the object corresponding to y. The most basic order of this type, interval orders, have been well studied, and some specific generalizations of interval orders have been discussed. However, it has not generally been realized that we can study precedence between objects in the same way we discuss intersection and containment, and this gives rise to a large number of natural new classes of partial orders. (Received September 21, 2010)

1067-AF-1545 **Alexander Soifer*** (asoifer@uccs.edu), University of Colorado, Boulder, CO 80309.
Chromatic Number of the Plane: Yesterday, Today & Tomorrow.

This is my favorite open problem in mathematics. In its 60 years of existence, the problem has withstood all assaults, using combinatorial, geometry, abstract algebra, topology, measure theory, graph theory, and set theory. This history of the problem (Yesterday) resembles that of the Four Color Problem. Yet, we cannot even confidently conjecture the answer among the four candidates: 4, 5, 6, or 7. The 60 years have not been wasted: we have a good number of exciting results (Today) — and we have challenging conjectures (Tomorrow).

Much of my recent "The Mathematical Coloring Book," Springer, New York, 2009, has been dedicated to this problem. In this talk, I will present some of the problem's Yesterday, Today, and Tomorrow. (Received September 21, 2010)

Alternative Approaches to Traditional Introductory Statistics Courses

1067-B1-27 **Anant Godbole*** (godbolea@etsu.edu), ESTU Math Department, Box 70663, Johnson City, TN 37614. *Teaching Introductory Statistics in Thirteen Formats.* Preliminary report.

At East Tennessee State University, most students are required to take Introductory Statistics as a general education class. Through a combination of innovation, necessity, and opportunity, we now offer thirteen different versions of this class. These include the Regular, Dual Enrollment, Stretch, 5 hour, Three-week, Biologically Enhanced, On-line, Goverrnor School, In-Service Teacher, Pre-Service Teacher, Add-On, Honors, and The Three Stooges versions. This talk will examine the need for each version, and explain key differences and similarities. (Received June 01, 2010)

1067-B1-51 **Milo Schield*** (schield@augsburg.edu), 2211 Riverside Drive, Augsburg College, Minneapolis, MN 55411. *Teaching Critical Thinking in a Statistical Literacy Course Using Odyssey: a Web-Based Discussion Forum.* Preliminary report.

Critical thinking is a central element of a statistical literacy course when statistical literacy is defined as the ability to read and interpret summary statistics in the everyday media. But teaching critical thinking is generally an instructor-intensive activity that is unsuitable for large classes or online classes. This paper analyzes the use of Odysseys2sense: a new online discussion forum that develops civil discourse and critical thinking through anonymous peer review. Odysseys2sense is structured as a game. Players get power based on anonymous comments from other players using rating criteria that involve civility, accuracy and conceptual integration. This program was first used by me in teaching a hybrid statistical literacy course and then used in teaching a full online statistical literacy course. Student feedback, grading and outcomes are presented along with the features, strengths and weaknesses of the program. This first use indicates that Odysseys2sense can encourage critical thinking in reading and interpreting summary statistics with minimal teacher involvement and in a way that is useful for grading, scaleable for large classes and usable in online classes. (Received July 04, 2010)

1067-B1-197 **Philip S. Marcus*** (philnjudy@yahoo.com), Department of Mathematics, Bradley University, Peoria, IL 61606. *Teaching Two Tailed Tests.* Preliminary report.

In introductory statistics classes, hypothesis tests are usually illustrated first with z tests and then with t tests. Because of the subtlety involved in deciding whether to use left tail, right tail or two tail hypotheses, which confuses many beginning students, z tests and t tests are not the best first examples of a hypothesis test for a possibly unsophisticated audience. For the past five years at Bradley University, students in some of the introductory statistics classes have been taught chi-square tests before z and t tests. Chi-square tests are interesting, useful and easy to understand. Students exposed to chi-square first have been able to manage the additional complexities of z and t tests as secondary complications which do not hurt the solid grasp of the essential concepts of hypothesis testing which they have learned in the automatically right tail environment provided by chi-square tests. A challenge involved in this approach is to make sure that when chi-square is included, there is still time for all the other usual topics of an introductory course - z tests, t tests, confidence intervals, correlation and regression. It is worth the effort. (Received August 01, 2010)

1067-B1-376 **Jeff Suzuki*** (jeff_suzuki@yahoo.com), 2900 Bedford Ave., Brooklyn, NY 11210.
Mathematics and the Law: Beyond People v. Collins.

The 1968 case of People v. Collins was a landmark case in the (ab)use of mathematics in the courtroom. But this case is more an example of a flawed application of probability and statistics. We will present several other cases which highlight the successful use of probability and statistics in a courtroom setting, with an eye towards how these cases might be incorporated into a traditional statistics course. (Received August 30, 2010)

1067-B1-527 **John C. Wagaman*** (jcwagaman@wcu.edu), 426 Stillwell Science, Western Carolina University, Cullowhee, NC 28723. *Some Active Learning Ideas in Introductory Statistics Courses.*

We have several courses at Western Carolina University which are introductory courses in statistics, which has motivated me to design activities for simultaneous use in multiple courses. Among these are a service course in applied statistics, a first course in calculus-based probability and statistics and a graduate course in experimental design. Each of these courses includes a data analysis component, so I try to use variables that promote interesting data collection applications. One such example is a card sorting activity that serves as an introduction to designed experiments, response and explanatory variables and analysis of variance. I have used a team spitball competition as a first lesson in correlation and regression. On class days that are a little calmer, we have used interesting survey questions to generate data and conversation among the class. (Received September 08, 2010)

1067-B1-730 **Kimberly A Roth*** (roth@juniata.edu), Juniata College, Brumbaugh Academic Center, 1700 Moore Street, Huntingdon, PA 16652. *Revising a course to meet the GAISE guidelines.*

In 2006 at Juniata College the introductory statistics course for math and science majors requiring calculus was very heavy on formal probability theory and formula, and light on real data and applications. After hearing about the GAISE guidelines at USCOTS 2007, I reformed the course to match GAISE. I will describe how I overcame the challenges of this change, including finding a new text and getting other colleagues to buy in to a new approach. (Received September 14, 2010)

1067-B1-840 **William R Harris*** (wharris@georgetowncollege.edu), Dept. of Math, Physics and Computer Science, Georgetown College, 400 E. College St., Georgetown, KY 40324. *A Biology-Emphasis Elementary Statistics Course in a Small, Liberal Arts College Setting.*

In Fall 2010, I taught for the second time a section of elementary statistics designated as "biology emphasis." At my institution, elementary statistics is a required course for biology majors; this course is my attempt to better provide these students the topics, techniques, and examples particularly relevant to their course of study. My talk will describe how this class differs from our "regular" statistics offering, how I used literature search assignments to reinforce the importance of statistics in biological research, and what I have learned from discussing statistics with my biology colleagues. (Received September 15, 2010)

1067-B1-922 **Pamela B. Omer*** (pomer@wnec.edu), Western New England College, Deptartment of Mathematics, 1219 Wilbraham Road, Springfield, MA 01119. *Success!Teaching Introductory Statistics Online.*

After teaching several semesters of Introductory Statistics Online, I have developed some techniques that have made the course very successful. I will discuss the use of MyStatLab (MSL) and Statcrunch along with other supplemental resources used in the course. The resources used in the online course can also be used for a hybrid or face to face delivery.

The student to student and student to instructor connection can be very difficult when teaching online. I have received very positive feedback at both the undergraduate and graduate level. This would be a great opportunity to share the structure of the course with others looking to teach statistics online or as a hybrid course. (Received September 16, 2010)

1067-B1-961 **Melinda Miller Holt*** (mholt@shsu.edu), Department of Mathematics and Statistics, P. O. Box 2206, Huntsville, TX 77340, and **Stephen M. Scariano** (sms049@shsu.edu), Department of Mathematics and Statistics, P. O. Box 2206, Huntsville, TX 77340. *Two-Way Tables: A Path Less Traveled.*

Although two-way contingency tables are certainly not new to elementary statistics courses, we contend that they are underutilized. In this presentation, we demonstrate the versatility of a single problem that may be interwoven throughout an entire introductory course, including college algebra-based and calculus-based courses, as well as beginning graduate service courses. Topical coverage includes, but is not limited to, relative frequencies, bar charts, probability, conditional probability, independence, Bayes' Theorem, odds, relative risk, statistical significance, and inference for decision-making. By introducing a two-way table as early as the first week of the course, instructors encourage informal inferential reasoning to lay the foundation for more formal concepts studied later, building on the framework of Zieffler et al. (2008). This avenue shows much promise, particularly in a problem-based learning environment as proposed by Lawton (2009). In addition, this approach of introducing and expanding discussion of two-way tables early in the course supports the first three GAISE College Report recommendations (Franklin & Garfield, 2006): to emphasize statistical literacy and develop statistical thinking, to use real data, and to foster active learning in the classroom. (Received September 16, 2010)

1067-B1-1002 **Daniel T Kaplan*** (kaplan@macalester.edu), Dept. of Math, Statistics, and CS, Macalester College, 1600 Grand Ave., Saint Paul, MN 55116. *Confounding the Traditional Introductory Statistics Course.*

The canonical culminating feature of a traditional introductory course is the t-test. The t-test provides a vehicle to present some concepts, but it poorly reflects contemporary statistical practice and it's of little use in introducing other important statistical concepts such as confounding and adjustment. At Macalester, we have designed an introductory statistics course oriented to take confounding and adjustment head on. The course uses multivariate linear models as the basis for descriptive and inferential statistics. To make this accessible to students without watering down the statistics or the mathematics, we have developed an innovative geometrical exposition of the linear algebra underpinnings, and we make extensive use of computation for simulations and randomization-based explorations (as well as for the conventional calculations). The course was developed as an experiment, but for the last five years, it has been the mainstream introductory statistics course, taken by fully one-quarter of the student body and required for majors as diverse as biology, economics, and mathematics. Student and faculty response has been extremely positive. (Received September 17, 2010)

1067-B1-1025 **Gina F Reed*** (greed@gsc.edu), P.O Box 1358, Gainesville, GA 30503. *Statistics for the Millenial Learner.*

There has been much discussion about the characteristics of millenial learners(i.e. students born after 1982). Several classroom applications were integrated into three introductory statistics courses in response to the Millenials' learning and behavioral characteristics. These included micro lectures using guided notes with an emphasis on real data and collaborative learning with immediate feedback. Examples of notes, assignments and student assessment results will be discussed. (Received September 17, 2010)

1067-B1-1047 **Michael A Posner*** (michael.posner@villanova.edu), Department of Mathematical Sciences, Villanova University, 800 Lancaster Ave, Villanova, PA 19085. *FREE CLICKERS!: Using PollEverywhere for Formative Assessment in the Classroom.* Preliminary report.

Formative assessment is where feedback on learning activities is used to modify the method of teaching to meet the needs of the learner. One such strategy is the use of personal response systems, or clickers, for instant feedback. Immediately examining the responses, teachers transcend the lecture-only model and are empowered to foster student-centered learning by explaining misconceptions or feeling confident that students understand the concepts. Attention is no longer deferred to the loudest student or the fastest hand-raiser, but rather to entire class. I have wanted to try clickers, but was reluctant due to the barriers of implementation - cost to the student and software and hardware demands, including students forgetting their clickers. I recently discovered polleverywhere.com, which allows students to text in their answers using cell phones and see the results immediately on either the screen. Results can be captured and shared with students on websites or blogs. And it's free for small classes. My students love it! I'll discuss my experiences and share how I have integrated some of the classic active-based exercises in statistics into my class and used formative assessment techniques that have helped bring my classroom to life. Bring your cell phones!!! (Received September 17, 2010)

1067-B1-1565 **Robert delMas*** (delma001@umn.edu), 250 Educational Sciences Building, 56 East River Road, Minneapolis, MN 55455, and **Joan Garfield** (jbg@umn.edu) and **Andrew Zieffler** (zief0002@umn.edu), MN 55455, and **Laura Le** (free0312@umn.edu), **Rebekah Isaak** (isaak009@umn.edu), **Jiyoon Park** (parkx666@umn.edu) and **Laura Ziegler** (sath0166@umn.edu). *A different flavor of introductory statistics: Teaching students to really cook.*

The NSF-funded CATALST project is developing a radically different undergraduate introductory-statistics course that uses randomization and resampling approaches as the only methods for statistical inference. Standard parametric tests of significance, such as the two-sample t-test and Chi-square analyses, are not taught in the course. Instead, a carefully designed sequence of activities based on research in mathematics and statistics education research help students develop their understanding of randomness, chance models, randomization tests and bootstrap coverage intervals. For each unit in this course, students first engage in a Model-Eliciting Activity (MEA; Lesh & Doer, 2003; Zawojewski, Bowman, & Diefes-Dux, 2008) that primes them for learning the statistical content of the unit (Schwartz, 2004). This is followed by activities where the students explore how to model chance and chance models using modeling software such as TinkerPlots and then transitioning to analysis tools built on the R framework to carry out randomization tests and estimate bootstrap coverage intervals. The talk will present activities from the first unit on chance and chance models to illustrate this approach. (Received September 22, 2010)

1067-B1-1600 **Edwin P Herman*** (eherman@uwsp.edu), Department of Mathematical Sciences, University of Wisconsin-Stevens Point, Stevens Point, WI 54481. *Papers? - in a math class? Using essays and online discussion groups to improve an Introductory Statistics course.* Preliminary report.

For many years I incorporated a capstone project in my Introductory Statistics sections: student groups would design a statistical project, gather data, then analyze and report their conclusions. These projects tied course ideas together well, but I gradually realized that most of the students would become consumers rather than creators of statistics.

In the summer of 2008, I took advantage of a curricular grant to hybridize my course. Instead of a single capstone project, students now have online readings and discuss contemporary topics such as global climate change and the economy. Each topic culminates in a short paper, using statistical arguments to support the thesis.

Based on student feedback, I have made modifications to the course format, including the amount of in-class time and the use of daily online quizzes. Although student feedback is mixed, I believe students at this level benefit more from critically interpreting existing data than from creating their own. (Received September 21, 2010)

1067-B1-1639 **John P Travis*** (travis@mc.edu), Box 4025, Clinton, MS 39058. *Seeing Statistics.* Preliminary report.

Introductory Probability and Statistics courses often have students creating answers without having any idea regarding the meaning of their numbers. Since a picture is worth a thousand words, it is often better to seek ways to help students visualize the statistics. In this talk, a graphical approach for presenting statistical results such as Bayes Theorem and the Central Limit Theorem will be presented through the use of interactive Sage worksheets. (Received September 21, 2010)

1067-B1-1747 **K. Scott Alberts*** (salberts@truman.edu), Dept. of Mathematics and Computer Science, 100 E. Normal St., Kirksville, MO 63501. *Deep Assignments: Getting Students to Think.* Preliminary report.

We all know that skills are learned through practice (and skills are a big part of learning statistics), but critical thinking and engaged learning takes something more. Getting students to apply a statistical eye to normal tasks like reading the newspaper or attending an outside lecture or research session need not be extra credit, but can be an integral part of even a first course in statistics. You might be surprised to see that English major demonstrating a great understanding of statistical independence in an essay that he was unable to demonstrate on your quiz. A student may not see why she needs statistics, particularly daily homework assignments, but she can find connections to something that matters to her(without you finding it for her).

For students ready for real thinking, including anyone beyond a first statistics class, they can find a data set for use in class, redo their homework assignment with the quality of an answer key, or apply their skills to your handouts. Do you know why that Wikipedia page is mediocre? Because your students haven't fixed it yet, silly.

Student survey data reveals satisfaction, and while exam scores remain constant, outcomes sought by Deep Assignments may not be directly measurable by exams. Indirect measures are in progress. (Received September 21, 2010)

1067-B1-1858 **Michael D. Miner*** (jcmhs77@aol.com), 65 Edenbrook Dr., Hampton, VA 23666. *Applied Statistics for Non-Traditional Undergraduate Business Majors (An Introductory Statistics Course).* Preliminary report.

BBA308 is an introductory Applied Statistic course for business majors who are non-traditional learners in a non-traditional learning environment. The course meets one night a week (6 – 10 pm) for seven consecutive weeks. The class duration is four hours and is designed for the working adult learner. As the primary instructor for this course for the last seven years, I have developed the course to address the major statistical concepts from an applied statistics perspective, enabling student success in what is perceived to be the most difficult course in the curriculum. This presentation and subsequent paper will highlight the course design that makes this course effective for the adult learner. Several of the learning activities along with the course project will be presented. (Received September 22, 2010)

1067-B1-1862 **Kumer Pial Das*** (kumer.das@lamar.edu), Beaumont, TX 77710, **Md. Shamim Sarker** (mssarker@my.lamar.edu), Beaumont, TX 77710, and **AKM Saiful Islam** (saif.saki@gmail.com), PO Box 10047, Beaumont, TX 77710. *Teaching an online Statistics Class for Education Major.*

According to the seventh annual Sloan Survey of Online Learning reveals that approximately 4.6 million students were enrolled in at least one online course in fall 2008 in the United States which is an increase of about 17 percent from a year earlier. Moreover, according to a 2009 meta study from the Department of Education: "Students who took all or part of their class online performed better, on average, than those taking the same course through traditional face-to-face instruction." Students who mix online learning with traditional coursework (i.e. blended learning) do even better. In this study, an attempt has been made to investigate the results obtained by the meta study. A traditional statistics course designed for education major has been compared with the same course delivered online. (Received September 22, 2010)

1067-B1-1906 **M. Leigh Lunsford*** (lunsfordml@longwood.edu), Dept. of Mathematics and Computer Science, Ruffner Hall 331, 210 High Street, Farmville, VA 23909, and **Alix D. Dowling Fink**. *Introductory Statistics and Science: A Collaborative Teaching Approach.*

We developed collaborative research projects which linked two introductory level honors courses, one in statistics and the other a general education science course. Our goal was to enhance the learning of the statistics and science by immersing our students in a rigorous, relevant and cross-disciplinary research project. In the course of one semester students in our two classes engaged in the entire research process from formulating their research question, designing and executing experiments to collect data to answer the question, analyzing the data, and presenting their results in a poster session. We will describe two projects, each administered in different semesters. The first was a bottled versus tap water taste test and the second was a plant growth experiment. Our talk will discuss pedagogical as well as logistical issues in linking two courses for collaborative research projects, including successes and lessons learned. (Received September 22, 2010)

1067-B1-1940 **Todd M Swanson*** (swansont@hope.edu), Mathematics Dept, 27 Graves Place, Holland, MI 49424-9000, and **Jill L VanderStoep** (vanderstoepj@hope.edu), Mathematics Dept, 27 Graves Place, Holland, MI 49424-9000. *An Active Approach to Statistical Inference using Randomization Methods.* Preliminary report.

We have significantly changed our introductory statistics course in both content and pedagogy. We use an intuitive approach to introduce inferential statistics using permutation tests and other randomization methods. This means that in the first week of the course students begin to understand the structure of a test of significance, what a sampling distribution is, and what a p-value means. This early introduction to the inferential statistical process allows us to cycle through the core logic of inference throughout the course. Therefore, we teach inference for an entire semester instead of just half a semester as is traditionally done. Because we spend more time with inference, our students develop a deeper understanding of the entire statistical process. We have also moved from a mainly lecture based class to one that is driven by group work, self-discovery, active-learning and tactile demonstrations using case studies, projects, and research articles. Our paper will include an overview of our curriculum, an example of a permutation test, sample class activities, and examples of student work. (Received September 22, 2010)

1067-B1-2053 **Pamela Omer*** (pomer@wnec.edu), Western New England College, Deptartment of Mathematics, 1219 Wilbraham Road, Springfield, MA 01119, and **Marilyn Pelosi** (mpelosi@wnec.edu), Western New England College, School of Business, 1219 Wilbraham Road, Springfield, MA 01075. *Looking for a semester long project to enhance student learning? We have one for you!*

We would like to introduce a semester long Introductory Statistics project that can be used in the traditional classroom, hybrid course or online. The project is broken up into four phases and any statistical software can be used. We plan to discuss the statcrunch program that is web based and ideal for connecting online students together. This project has been used with Undergraduate and Graduate students. (Received September 22, 2010)

1067-B1-2057 **Audbjorg Bjornsdottir*** (audbjorgb@gmail.com), 3834 ewing ave south, minneapolis, MN 55410, and **Joan Garfield**, MN. *Using group quizzes in an online introductory statistics course.* Preliminary report.

This presentation describes the design and implementation of group quizzes in an online introductory statistics course. Three group quizzes were designed and administered in a 15-week online course as part of an assessment plan that included group discussions, individual homework, midterm and a final. Group quizzes were introduced based on educational research that suggests use of collaborative assessments may lead to higher exam scores (Rao, Collins & DiCarlo, 2002; Sandahl, 2009), positive changes in students' attitudes toward testing (Giraud, 1998), a decrease in test anxiety, as well as improved peer relations, thinking skills and motivation (Sandahl, 2009). Groups used discussion tools in Web Vista to work on a quiz, over a five-day period. To receive a full grade students answered the quiz individually, posted answers and provide at least two comments to other group members' answers. Each group turned in one copy of a quiz; a consensus regarding answers was required. Our results indicate that group quizzes can benefit both students and instructors when used as part of an overall assessment plan in online courses. They can help students learn and communicate, utilized collaborative learning in an assessment format, and decrease time needed to read and grade assessments. (Received September 22, 2010)

1067-B1-2075 **Robin H Lock*** (rlock@stlawu.edu), Dept. of Math, CS and Stat, St. Lawrence University, Canton, NY 13647, and **Patti Frazer Lock**, Dept. of Math, CS and Stat, St. Lawrence University, Canton, NY. *Early Inference: Using Bootstraps to Introduce Confidence Intervals.*

Is it feasible to teach important ideas of statistical inference, such as constructing and interpreting a confidence interval for a population parameter, early in an introductory course - even before students see a normal distribution? We argue that bootstrapping and randomization techniques make this possible and can facilitate students' understanding of the underlying concepts. We describe revisions to a general-audience, introductory statistics course designed to give students an early introduction to inference, starting with constructing confidence intervals based on a distribution of bootstrap statistics. These techniques are quite general - students can find a confidence interval for a standard deviation or correlation as easily as a mean - and require relatively few statistical prerequisites. We describe some of our experiences with test driving this approach in a course this fall. (Received September 22, 2010)

1067-B1-2220 **Chris J Malone*** (cmalone@winona.edu), PO Box 5838, Winona, MN 55987, **Tisha L Hooks** (thooks@winona.edu), PO Box 5838, Winona, MN 55987, and **April T Kerby** (akerby@winona.edu), PO Box 5838, Winona, MN 55987. *Consequences of Resequencing Topics in an Introductory Statistics Course.*

Malone et al. (2010) discussed the need for the resequencing of topics in an introductory statistics course. One consequence of this resequencing is the introduction of sampling distributions which are often introduced midway through the semester and centered around normal theory methods. The research of Holcomb et al. (2010) and the attendance at a recent CATALYST workshop motivated the current approach for introducing sampling distribution and statistical inference. This approach involves the use of hands-on activities and simulations which lead to commonly known statistical tests (e.g. binomial and Fisher's exact test). These changes have improved our students' understanding of sampling distributions and the use of a p-value as a measure of extremeness. (Received September 22, 2010)

1067-B1-2270 **Kari F. Lock*** (lock@stat.harvard.edu), Statistics Department, Harvard University, Cambridge, MA 02138, **Eric F. Lock** (lock@email.unc.edu), Statistics Department, University of North Carolina at Chapel Hill, Chapel Hill, NC 27510, and **Dennis F. Lock** (dennis.f.lock@gmail.com), Statistics Department, Iowa State University, Ames, IA 50014. *Early Inference: Using Randomization to Introduce Hypothesis Tests.*

Traditional ways of teaching hypothesis testing (t-tests, z-tests, etc.) require teaching students a great deal of theory before the core concepts of statistical inference can be introduced. Randomization tests free us from these confines, and allow hypothesis testing to be taught early on, giving students an understanding of the key idea of statistical inference early in the course. Also, while traditional methods lead students to focus on the mechanics of carrying out a hypothesis test, randomization-based methods lead students to understand more clearly what a p-value actually represents. We discuss how randomization methods can be used with little background knowledge to teach the idea of statistical significance, and why such an approach might yield a deeper understanding of hypothesis testing. (Received September 22, 2010)

1067-B1-2349 **Max Buot*** (buotm@xavier.edu), Department of Mathematics & Computer Science, Xavier University, 3800 Victory Parkway, Cincinnati, OH 45207. *Data Visualization in Introductory Statistics.*

The standard graphical displays of univariate data that are studied in the early weeks of an introductory statistics course are well suited to visualize variability, outlying data values, and measures of location. To examine the relationship between two or more variables, a side-by-side graph, or in the case of quantitative data, a scatterplot, is constructed. These displays are sufficient for a first course in statistics, but students often perceive them as bland and uninspiring. As a counter to this impression, I supplement lectures with examples of data visualizations that are employed in modern research (but not mentioned in the course text). Students have found these displays aesthetically pleasing, as well as an effective means to illustrate multivariate relationships. Although their construction is beyond the scope of an introductory course, the presentation of an advanced graphical display usually provides students some insight as to how a data set should be analyzed. In this talk, I will discuss how bubble charts and heat maps can help motivate many of the topics covered in a traditional first course in statistics. Each example is either found online, or readily duplicated with the open-source statistical package R. (Received September 22, 2010)

1067-B1-2359 **Sheldon H Lee*** (shlee@viterbo.edu), Viterbo University, 900 Viterbo Drive, La Crosse, WI 54601. *Online discussions boards: An attempt to foster student interaction and engagement in an online Introductory Statistics course.*

We often object to offering online mathematics courses because of the lack of face to face interaction with and between the students, but pressure to offer online courses seems to only increase with time. The standard tool for closing the gap between online and traditional experiences is the discussion board, but to what effect can it be used in an introductory statistics course? It is a challenge to guide students into a meaningful and helpful discussion that is generally open-ended. In this talk, I will share my implementation of a discussion board, the challenges that I experienced, and student feedback. As this was my first attempt at utilizing a discussion board in an introductory statistics course, I welcome audience suggestions and feedback. (Received September 22, 2010)

Cool Calculus: Lessons Learned Through Innovative and Effective Supplemental Projects, Activities, and Strategies for Teaching Calculus

1067-C1-251 **Brian Birgen*** (brian.birgen@wartburg.edu), 100 Wartburg Blvd, Waverly, IA 50677, and **Mariah Birgen** (mariah.birgen@wartburg.edu), 100 Wartburg Blvd, Waverly, IA 50677. *Using Modeling and Differential Equations with a Numerical Solver to Teach First Year Calculus.* Preliminary report.

Historically the first year of Calculus has consisted of courses in Differential and Integral Calculus designed to meet the needs of Engineering majors. Many students take only the first course in this sequence and never make the connections between Calculus and their area of future studies.

At Wartburg College we have completely redesigned the Calculus sequence. Students begin with Applied Calculus, a course on Modeling and Differential Equations, in which students use a numerical solver to analyze and solve a variety of problems. Students who take only one Calculus course are exposed to the applications and power of the discipline, without getting lost in the formalism.

In the second semester students take Foundational Calculus, an intense development of Differential and Integral Calculus without applications and a focus on symbolic manipulations. Online mastery based homework as well as challenging group homework are aspects of this course to assure that students learn the material to the necessary depth.

Preliminary results show that students persevere through the first semester Calculus course at a higher rate, and that students are comparably prepared for sophomore level math classes. (Received August 13, 2010)

1067-C1-357 **Michael D Smith*** (msmith5@hollins.edu), PO Box 9516, Roanoke, VA 24020. *Sharks, Minnows and Wheelbarrows: Calculus Modeling Projects.*

The purpose of this talk is to present two very active applied modeling projects that were successfully implemented in a first semester calculus course at Hollins University. The first project uses a logistic equation to model the spread of a new disease such as swine flu. The second project is a human take on the popular article "Do Dogs Know Calculus," written by Tim Pennings. These projects take interactivity to new levels in math courses by actually requiring the students to engage in physical activity to generate the facts that they will analyze using calculus, while also presenting students with a life lesson to take with them after the course. The benefits that students get from these projects far outweigh the loss of the small amount of lecture time required to collect the necessary data. In addition to discussing these projects, a major portion of this talk will discuss practical and pedagogical lessons learned from implementing these projects. The paper which corresponds to this talk has been accepted by the refereed journal PRIMUS and is scheduled to appear in 2012. (Received August 26, 2010)

1067-C1-397 **Nathan M Wodarz*** (nwodarz@uwsp.edu), Department of Mathematical Sciences, University of Wisconsin - Stevens Point, 2100 Main Street, Stevens Point, WI 54481.
Putting the Cart before the Horse? Teaching Differentiation Rules as "Review" in First Semester Calculus.

Many students enter first semester calculus courses with prior exposure to the subject. This can lead to problems in two different ways. Students who have previously had a calculus course are frequently overconfident in their skills. Meanwhile, other students may worry that they are starting off well behind the first group. In both cases, students mistake computational skill for true understanding of the material. We discuss the results of one attempt to remedy this misconception - trying to level the playing field by immediately teaching differentiation techniques at the start of the semester. We analyze student proficiency in both applying these rules and conceptual understanding of calculus. These results are compared with a similar analysis of a class taught in a more traditional manner. (Received August 31, 2010)

1067-C1-986 **Anneke Bart*** (barta@slu.edu), 220 N. Grand Blvd, St. Louis, MO 63103. *Engaging students through the use of the online homework system WeBWorK.* Preliminary report.

WeBWorK has been used at Saint Louis University for a couple of years and we have experienced an increased level of communication with our students. Furthermore, data collected shows a very strong correlation between WeBWorK grades and final course grades.

A description will be given of our use of WeBWorK, and its effect on student participation, communication and the effect on final grades. (Received September 17, 2010)

1067-C1-1457 **Philip B Yasskin*** (yasskin@math.tamu.edu), Department of Mathematics, Texas A&M University, 3368 TAMU, College Station, TX 77843-3368, and **Douglas B Meade** (meade@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Maplets for Calculus: Effective Teaching and Studying Resources for Calculus Students.*

Learning calculus is not a passive activity. As university resources continue to be stretched, section sizes have increased and grading support has declined. With limited resources, more courses are making use of computer-based homework systems. Unfortunately, most of these systems still have pedagogical limitations.

Maplets for Calculus (M4C) is an electronic study guide that consists of 129 customized applets for specific topics in precalculus, univariate calculus and multivariate calculus. Each applet presents an algorithmically-generated problem, requires correct intermediate responses before moving on to the next step, employs computer algebra to analyze student responses and provides customized hints and feedback. Graphics (2D, 3D, animation and stereo) are used whenever possible to reinforce the symbolic mathematics. In short, M4C is a "tutor without the tutor".

Students appreciate the step-by-step guidance through problems and the way algebraic, graphic, numeric and verbal approaches support diverse learning styles. Instructors like the interactions that arise when students in a lab have different versions of similar problems and frequently use the applet graphics as lecture demonstrations. Initial assessment of M4C's effectiveness is underway. (Received September 21, 2010)

1067-C1-1647 **Paul E Seeburger*** (pseeburger@monroecc.edu), 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 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 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 three years of assessment results will be shared, although the focus of the talk will be on the applet itself. The grant project is titled, Dynamic Visualization Tools for Multivariable Calculus (NSF-DUE- CCLI #0736968). See http://web.monroecc.edu/calcNSF/. (Received September 22, 2010)

1067-C1-1662 **Amit A Savkar*** (amit.savkar@uconn.edu), 196 Auditorium Road, Department of Mathematic, U-3009, Storrs, CT 06269, and **Fabiana A Cardetti** (fabiana.cardetti@uconn.edu), 196 Auditorium Rd, Unit 3009, Storrs, CT 06269. *Calculus in large lectures: Pedagogy through technology.* Preliminary report.

In recent years many colleges and universities have been shifting their calculus classes from small size (30-35 students) to large lecture format (more than 150 students). As a result of the change many issues have resurfaced that have diluted the pedagogical influence of teaching first year calculus. Among those issues are the lack of student engagement, the lack of interaction between students and their instructors, and the need for students to find better study strategies. Many instructors are now, more than ever before, interested in learning how to incorporate instructional technologies to help improve the teaching and learning experiences in these courses. In this talk we will share with you how we have tackled these issues using three different technological resources aimed at improving in-class participation, enhancing the student-teacher interaction, as well as helping students organize their study materials. We will also present the details of an ongoing research study designed to assess the effects of these approaches on students' perceptions and achievement. (Received September 21, 2010)

1067-C1-1951 **Mike Long*** (malong@ship.edu), 11 Independence Drive, Shippensburg, PA 17257. *A Hands-On Approach To Calculus.*

This Project introduces hands on / active learning strategies in a traditional calculus class. Quantitative assessment results from this class were compared with a second traditional calculus class where only lecture was used. Qualitative assessments were also used to determine depth of students learning in the class where the alternative strategies were introduced. Students' reflections on the active learning strategies were also analyzed. (Received September 22, 2010)

1067-C1-2274 **Jason H Martin*** (Jason.H.Martin@asu.edu), RIMSE, Arizona State University, P.O. Box 873101, Tempe, AZ 85287-3101, and **Michael C Oehrtman** (Michael.Oehrtman@unco.edu), Campus Box 122, University of Northern Colorado, Greeley, CO 80639. *Overcoming Conflicting Imagery in the Development of an Understanding of Taylor Series Convergence.*

We present results from an exploratory research study and a subsequent teaching experiment revealing key aspects of university students' reasoning and learning about Taylor series. A detailed analysis of responses on questionnaires and clinical interviews revealed many students applying conflicting imagery from previously developed function and sequence concepts on tasks related to Taylor series. For example, some of these conflicting images were adaptations of stretches and shifts of graphs of functions. Others reflected convergence to a horizontal asymptote with significant confusion between the index and independent variable. The teaching experiment directly addressed these inconsistencies, highlighting visual attributes of pointwise convergence and establishing a coherent language based on approximation and error analyses. We scaffolded tasks to develop an image of pointwise convergence as convergence of series along vertical number lines corresponding to particular values of the independent variable. The students in the teaching experiment internalized these images and approximation language that supported sophisticated reasoning about the structure of Taylor series. (Received September 22, 2010)

1067-C1-2352 **Tevian Dray*** (tevian@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331. *Using Differentials to Teach Calculus Coherently.*

For the last 40 years, differentials have been taboo in calculus, having been turned into something else entirely: a tool for linear approximations. While mathematicians can be justly proud of the rigor introduced in the 1800s, we seem to have forgotten that calculus was used successfully before then, let alone that those early methods were rigorously justified in the 1960s. Many scientists and engineers apply calculus by manipulating differentials, and for good reason: it works.

We report here on our efforts to make differentials the central theme in calculus, initially through our very successful 15-year effort to bridge the gap between lower-division mathematics and upper-division physics, then through our much less successful attempt to apply what we had learned to first-term calculus. Although some of our evidence is anecdotal, we also have qualitative evaluations based on student work in vector calculus, as well as data obtained with the Calculus Concept Inventory (CCI). (Received September 22, 2010)

1067-C1-2362 **Sarah L Mabrouk*** (smabrouk@framingham.edu), Framingham State University, 100 State Street, PO Box 9101, Framingham, MA 01701-9101. *Use of Open-Ended Problems in Multivariable Calculus.*

Open-ended problems provide opportunities for students to apply the concepts and methods that they study and learn as well as to model real-life situations. Learning to assign a coordinate system, understanding how to describe/model real objects using equations/functions of more than one variable, and comprehending how to model motion using vector-valued functions or to determine the optimal value of a function of more than one variable are important for any student of multivariable calculus. In this presentation, I will discuss the effect of the use of assignments/projects linking open-ended problems with real-life objects and applications on student learning and understanding of vector-valued functions and motion, lines, planes, and surfaces, and optimization problems. (Received September 22, 2010)

Cryptology for Undergraduates

1067-C5-446 **Todd Feil*** (feil@denison.edu), Dept. of Mathematics and Computer Science, Denison University, 100 College St, Granville, OH 43023. *A Cryptology Course for the Non-Mathematician.*

A description of a course given many times at Denison to students who are non-mathematics and, largely, non-science majors (fulfilling a general education requirement). Topics and assignments are covered including development of statistical aids in helping decrypt messages, RSA with accompanying number theory, and the Enigma. Software that softens the more tedious work is also demonstrated. (Received September 03, 2010)

1067-C5-543 **Stuart Boersma*** (boersmas@cwu.edu), Department of Mathematics, Central Washington University, 400 E University Way, Ellensburg, WA 98926. *Student Codebooks: An in-depth writing assignment.*

In order to help students synthesize mathematical ideas through writing, a major part of students' grades in an upper-level cryptology course are determined by the creation of a five chapter *Codebook*. Each chapter of the *Codebook* contains 1) a description of a specific cipher that is being studied, 2) examples of enciphering and deciphering for that particular cipher, 3) a careful description of a cipher-text only attack, and 4) an illustration of such an attack. *Codebooks* were assessed on their organization, clarity, and correctness. Revisions were encouraged after initial instructor feedback. A complete description of this assignment will be presented along with examples of student work. (Received September 08, 2010)

1067-C5-706 **Daniel Cabarcas*** (cabarcd@mail.uc.edu). *Algebraic Cryptanalysis as a tool for teaching Cryptology.*

This work originates from the experience of three summer REUs in mathematical cryptology organized jointly by Chris Christensen (Northern Kentucky University) and Jintai Ding (University of Cincinnati) between 2008 and 2010. The central theme of the program was algebraic cryptanalysis, that is, breaking cryptosystems by solving systems of polynomial equations. We will summarize the experience highlighting the role played by algebraic cryptanalysis as a pedagogical tool for teaching cryptology. (Received September 13, 2010)

1067-C5-811 **Don Spickler*** (despickler@salisbury.edu), Salisbury University, 1101 Camden Ave., Salisbury, MD 21801. *Cryptography Tools: A Teaching Tool for the Investigation of Classical Cryptography and Cryptanalysis.*

The Cryptography Tools program was developed for the investigation of classical cryptography and cryptanalysis. The ciphers the program supports are mono-alphabetic substitution, Vigenere, Playfair, ADFGX, ADFGVX, LFSR, Hill, Enigma, and RSA. In addition the program has several tools to aid in the cryptanalysis of some of these ciphers. There are facilities to do frequency analysis, shift analysis, dot product analysis, determinant analysis and a facility to compare substrings. There are text extractors, combiners and converters to manipulate ciphertext. There is an infinite precision integer calculator as well as facilities for the calculation of probable primes and random numbers. The Cryptography Tools program was designed to remove the tedious calculations from the cryptanalysis process while still leaving the main decisions up to the user. The Cryptography Tools program is cross-platform and can be downloaded from my web site at http://facultyfp.salisbury.edu/despickler/personal/CryptTools.asp. In this talk we will discuss the main features of the program along with how it was used in a special topics course, for majors, in cryptography at Salisbury University and how it could be used in a course for non-majors. (Received September 15, 2010)

1067-C5-1192 **Kay E. Smith*** (smithk@stolaf.edu), Saint Olaf College, 1520 Saint Olaf Avenue, Northfield, MN 55057. *Codes in History, the Arts, and Literature.*

Codes have played an important part in history and have been used by writers, painters, and musicians. In this talk we describe some of these historical events and artistic uses of codes, which can provide enrichment or project topics in courses for majors or non-majors. Examples include: Thomas Jefferson's interest in cryptography, the Zimmerman telegram and America's entry into World War I, Edgar Allan Poe's story "The Gold Bug" and the Sherlock Holmes story “The Adventure of the Dancing Men,” the painter Auguste Herbin’s “Alphabet Plastique,” and jazz musician Rudrish Mahanthappa’s recording “Codebook.” (Received September 20, 2010)

1067-C5-1315 **Kristi Meyer*** (kristi.meyer@wlc.edu), 8800 W. Bluemound Rd., Milwaukee, WI 53226. *Making Cryptography Come Alive.*

Cryptography is often treated as just another “sterile” mathematics subject. Although applications are often discussed in an introductory cryptography class, the “real-life stories” may be pushed aside in favor of mathematical content. Unfortunately, these real-life stories are often the most interesting part of cryptography for students and are wonderful examples of the practicality of the subject. In this talk, I will detail how I exposed my students to the human side of cryptography through the use of a research paper and presentation. Chosen research topics will be discussed, as well as grading issues and student feedback. (Received September 20, 2010)

1067-C5-1356 **Mike May*** (maymk@slu.edu), SLU, Dept of Math & CS, 220 N Grand Blvd, St Louis, MO 63103. *Using Cryptography to Show Students that Math is Everywhere.* Preliminary report.

A useful fact about cryptography is that in our current culture it is practically impossible for our students to avoid using cryptography on a routine basis, even if they do not initially realize this fact. A standing assignment in my class is that students must routinely make an annotated discussion group posting of a URL related to cryptography. They must also make comments evaluating the information found in other students’ posting. Several times a semester they must write a one-page evaluation of a site. The net result is that they become aware not only that ”math is everywhere”, but that it is also pervasive and in plain sight but they have not been seeing it. (Received September 20, 2010)

1067-C5-1428 **Robert A Beezer*** (beezer@ups.edu), Department of Mathematics, #1043, University of Puget Sound, 1500 N. Warner, Tacoma, WA 98416-1043. *A first-year seminar in cryptology.*

“The Art and Science of Secret Writing” is a first-year seminar course in cryptology taught at the University of Puget Sound. Every first-year student is required to take a seminar course, which are offered in a wide variety of disciplines. These courses are not allowed to have significant prerequisites, so that they are each possible for any member of the entering class.

Still, much interesting cryptology can be developed with simple ideas like modular arithmetic and bit-wise operations. This presentation will explicitly describe approaches and materials that worked well, and those that did not, based on teaching the course three times, with substantial revisions for each new offering. The course has an historical component (e.g. classical ciphers), a modern component (e.g. DES, RSA) and a public policy component (e.g. Clipper chip, DMCA).

Even for an audience of students with minimal preparation in mathematics there are many fun and interesting activities that demonstrate the power of mathematics, its place in history, and the debates it continues to trigger today. (Received September 21, 2010)

1067-C5-1816 **Peter J. Littig*** (plittig@uwb.edu), University of Washington, Bothell, Science and Technology Program, 18115 NE Campus Way, Bothell, WA 98011. *How to Construct a Spy Dossier.*

What could be more appealing than mathematics, spies, and secret codes? In this talk I will give a brief overview of the interdisciplinary cryptography course I teach and then describe the course’s central project: the spy dossier. The project is a quarter-long, team-based assignment in which students play the role of agents working for a secret intelligence agency. The spy story unfolds through a series of encrypted messages that students must crack using the techniques learned in the course (e.g., frequency analysis, index of coincidence, Babbage’s Vigenere attack, etc.) I will conclude with a few remarks about Dossier 2.0, the latest stage of the project’s evolution. (Received September 21, 2010)

1067-C5-1942 **Aihua Li*** (lia@mail.montclair.edu), 1 Normal Avenue, Montclair, NJ 07043. *Cryptography, a Great Topic for Undergraduate Mathematics Courses.*

In this talk, I will share with the audience my experience in teaching cryptography to undergraduates. Cryptography is a great topic to be introduced to undergraduate students of any major, especially math and computer science majors. The fascinating underlying mathematics, its broad interdisciplinary feature, and the wonderful applications in the current hot area of communication security, make this topic a rich and attractive one to our majors. My students enjoyed the cryptography class very much and they showed great motivation and enthusiasm in the course activities, such as group projects that lead them to explore encryption and decryption procedures themselves. Through doing the projects, students raised the level of their mathematics skills, critical thinking, logical reasoning, and their appreciation of the mathematical ideas. As an elective course for our math majors, this class introduces the history of cryptography, basic concepts and underlying mathematics, and several simple cryptosystems. I also introduced simple cryptosystems and the underlying mathematics to a general education class for non-science majors. Those students were also amazed by the topic. (Received September 22, 2010)

1067-C5-2059 **Robert Talbert*** (rtalbert@franklincollege.edu), Department of Mathematics and Computing, Franklin College, 101 Branigin Boulevard, Franklin, IN 46131. *A Brief Fly-Through of Cryptology for First-Semester Students using Active Learning and Common Technology.*

In this talk we describe the instructional design of a multiple-day interactive unit on cryptology for students in the one-credit activity course "Introduction to the Mathematical Sciences" at Franklin College. The cryptology unit is intended to convey the major ideas and developments in cryptology, teach students some of the basic mathematical tools of cryptology (probability, modular arithmetic, binary arithmetic, etc.), and give students a sense of the range of applications of modern mathematics. Several factors mitigate the design of the unit. First, the students are mostly first-semester freshmen in their third week of college. Second, we assume the students' mathematical background is just three weeks of Calculus I (and prerequisites). Third, the class is an activity course, so there is no homework given. In order to maximize student learning in this context, the unit is driven by a series of discovery activities enabled by readily-accessible technology such as spreadsheets and Wolfram|Alpha. (Received September 22, 2010)

1067-C5-2202 **Cheryl L. Beaver*** (beaverc@wou.edu), 345 N. Monmouth Ave., Monmouth, OR 97361. *Group Signature Schemes: How to share a secret without telling it.*

A cryptographic digital signature is used to mathematically verify the author of a message. The person who holds the secret key used in the signature algorithm is the only person who could have produced the signature. But can a digital signature fairly represent a group of people? It can as long as the secret key is shared among the group members in such a way that no one person knows the key. The mathematics behind secret sharing schemes is quite simple and appropriate for undergraduates. We will explore how these schemes work and how the concept can be extended to develop cryptographic group signature schemes. (Received September 22, 2010)

Developmental Mathematics Education: Helping Under-Prepared Students Transition to College-Level Mathematics

1067-D1-255 **Shumei C. Richman*** (richmansm@aol.com), 220 N. woodlake Dr., Columbia, SC 29229. *On The Teaching of the Three Methods for Solving a Linear Inequality in Two Variables.* Preliminary report.

For solving a linear inequality in two variables, most commonly available textbooks use a one-point test to determine the half-plane solution after the boundary line is located using the corresponding equation. In this paper, we propose to also include two alternative methods: Variable Reduction and One-Coefficient Test. Our discussions aim to answer two questions: 1. Is it sufficient to teach only one-point test method? and 2. Do the benefits of teaching more than one method out-weight the extra time spent? Our analysis is based on our understanding of the possible impacts of a formula approach and its corresponding concept approach on students' math learning, now in beginning algebra and beyond. (Received September 18, 2010)

1067-D1-435 **Zhixiong Chen*** (zchen@njcu.edu), Department of Mathematics, New Jersey City University, 2039 Kennedy Blvd, Jersey City, NJ 07305. *Teaching Developmental Mathematics in Urban University.*

New Jersey City University is an urban public higher education institution in the state of New Jersey. Every semester a large amount of under-prepared students enroll in developmental mathematics courses. In this presentation, history and background of teaching developmental mathematics in the department will be introduced; efforts made by the faculty members and the department to improve these course teaching in recent years will be discussed. Also, I will share the experience of coordinating these courses. (Received September 03, 2010)

1067-D1-504 **Aaron Wong*** (aaron.wong@nsc.nevada.edu), 1021 East Paradise Hills Drive, Henderson, NV 89002. *Modularized Math Remediation: Completely Overhauling the Broken System.*

The mission of Nevada State College is to increase access to higher education within our region. However, our region is among the lowest in the nation in mathematical achievement, so our students are coming to us with a very weak mathematical background. Most of our students need to be remediated from the level of prealgebra. We have over 350 students taking remedial math courses every semester (out of a student population of 2500). The traditional approach has not been very successful. Because of the high correlation between success in math remediation and overall academic success, we were charged with the task of creating a system to increase student achievement, while maintaining high standards. Our efforts have led us to completely revamp both the administrative structures behind and delivery of our remediation classes. This preliminary report will lay out major components of our strategy and our plans to bring it to fruition. (Received September 07, 2010)

1067-D1-768 **Kimberly J Presser*** (kjpres@ship.edu), 23 Glenwood Drive, Biglerville, PA 17307.
Tracking and Ability Grouping: Alternative srategies for serving a growing population of students needing developmental mathematics education. Preliminary report.

In light of tighter resources and a growing number of under-prepared students coming to our mathematics courses at the university level, institutions are struggling to find affordable ways to provide quality remediation to students. One growing trend is course redesign, such as those funded by the National Center for Academic Transformation (NCAT), which use technology to redefine the learning model and allow for more students to be served by faculty than in the traditional classroom model. The scale and totality of these redesign efforts lend themselves to large institutions with extremely large numbers of students requiring developmental education or institutions with access to technology wich can be dedicated for these efforts.

For institutions with smaller (yet still growing) numbers of developmental mathematics students, alternative strategies may be considered before such a drastic redesign program. In our case, we are looking at a version of tracking to provide the most help to those students who are in need of the most remediation. This has allowed us to shuffle our resources and service more students with the same number of faculty. This paper will focus on the background data, our implementation methods and some preliminary results. (Received September 14, 2010)

1067-D1-1052 **Leonid Khazanov*** (lkhazanov@bmcc.cuny.edu), Borough of Manhattan Community College/CUNY, Department of Mathematics, 199 Chambers Street, New York, NY 10007, and **Fred Peskoff** (fpeskoff@bmcc.cuny.edu), Borough of Manhattan Community College/CUNY, Department of Mathematics, 199 Chambers Street, New York, NY 10007.
Mentoring At-Risk Students in a Remedial Mathematics Course.

A peer mentoring program has been implemented to support a group of at-risk students enrolled in two sections of an elementary algebra course at an urban community college. Peer mentors were recruited from advanced mathematics classes and trained to provide individualized tutoring and mentoring support to at-risk students. The results show that at-risk students performed, on average, as well as other students in their class and the retention rate for these students was higher. This paper is intended for instructors teaching developmental mathematics and administrators looking for innovative ways to improve passing rates and student retention in developmental mathematics courses, as well as success in subsequent college level courses. (Received September 17, 2010)

1067-D1-1578 **William O. Bond*** (bondwil@uab.edu), Dept. of Mathematics - CH452, University of Alabama at Birmingham, Birmingham, AL 35294-1170, and **John C. Mayer** (jcmayer@uab.edu). *Can Inquiry-Based Learning Augment Computer-Assisted Instruction in Developmental Algebra?*

In an experiment being conducted in Fall Semester, 2010, we compare the effect of incorporating inquiry-based learning sessions versus traditional lecture sessions in a developmental algebra course in which the primary pedagogy is computer-assisted instruction. We hypothesize that blending-in inquiry-based learning sessions benefits students in terms of mathematical content knowledge as well as problem-solving ability. We use a quasi-experimental design: all students receive the same computer-assisted instruction component in a once-weekly meeting. At the start of the term, we divided the students in each section randomly into three subsections receiving different treatments for two additional weekly meetings: (1) two lecture meetings, (2) one lecture meeting and one inquiry-based meeting, or (3) two inquiry based meetings. Measures, including pre- and post-tests, with both objective and rubric-scored parts, are described. Statistically significant differences between treatments have previously been observed in a similar study of multiple sections of a Finite Mathematics course in Fall, 2008, and a study of the same developmental algebra course with two treatments in Fall, 2009. (Received September 21, 2010)

1067-D1-1629 **Dale J Winter*** (amanita@andrew.cmu.edu), 5000 Forbes Avenue, Pittsburgh, PA. *Supporting the high school to highly demanding university transition for ESL learners in an environment of strong ethnic and cultural diversity: The case of Carnegie Mellon University in Qatar.*

For six years, Carnegie Mellon University (CMU) has operated a campus in Qatar. Courses are taught to the rigorous standards of CMU's main campus. Students identify with a wide variety of ethnic groups, cultural traditions and varying levels of English proficiency. The high school backgrounds of entering students reflect additional diversity in terms of educational philosophies, academic rigor and socioeconomic status. In this talk we will describe the evolution of the university's academic support center. We will describe some of the specific issues and challenges met by the center in the area of developmental mathematics. In addition, we will describe some of the programs that we have implemented to assist students as transition to a highly competitive, demanding, and academically intense educational environment. Finally, we will provide data to illustrate areas of program effectiveness. (Received September 21, 2010)

1067-D1-1704 **Gary W. Hagerty*** (garyhagerty@boisestate.edu), 1910 University Dr, Boise State University, MS 1556, Boise, ID 83725-1556. *Leaving the Text Behind and Bringing Real-World Major Based Activities in to the Intermediate Algebra Course on a Weekly Basis.* Preliminary report.

In 2004, the MAA'S Committee on the Undergraduate Program in Mathematics (CUPM) advocated for a closer connection between mathematics and other disciplines, such as the sciences. In this talk, we will develop the rationale behind creating weekly activities focused on real-world problems from the major fields of study of our students. These activities connect the mathematical knowledge of the course directly to applications of interest to the students, thereby increasing the perceived relevancy of the mathematics. We will explain why and how this project is different from other projects we have seen. We will discuss the educational theories that support the addition of real-world problems based in each students major (yes, this means different activities for students planning to major in different majors), consider issues relating to the affective domain, offer suggestions for implementation issues, and consider preliminary results. (Received September 21, 2010)

1067-D1-1811 **J Bradford Burkman*** (bburkman@lsmsa.edu), 715 University Pkwy, Natchitoches, LA 71457. *Using Arithmetic of Integers as a Bridge to Arithmetic of Polynomials.*

When students learned to multiply 67×89, they actually multiplied $7 \cdot 9$, $60 \cdot 9$, $7 \cdot 80$, and $60 \cdot 80$ and added the results, a method that extends to 567×89. When they learned to multiply $(6x + 7)(8x + 9)$, they learned a cheap gimmick, FOIL, which does not extend to $(5x^2 + 6x + 7)(8x + 9)$. They did not understand that the methods for arithmetic of polynomials are perfectly analogous to those for integers. Students think that FOIL, the Distance Formula, the Midpoint Formula, and equations of lines are some kind of mysterious magic.

Would our developmental classes be more successful if we started back with arithmetic of integers and fractions, and taught students to understand those familar processes in a way that will transfer to arithmetic of polynomials and rational functions? Perhaps, but for many students, long multiplication is not a "familiar process," and to assign elementary-school math might feel condescending.

Over the years I have incorporated into my classes more topics that look advanced but whose goal is to practice basic arithmetic skills. The session will highlight several examples of how to get students to practice arithmetic of integers and basic geometry, and help them apply that knowledge to algebra topics. (Received September 21, 2010)

1067-D1-1859 **Darcel Ford*** (dford64@comcast.net), 5403 Riverfront Dr, Palmyra, NJ 08065. *Remedial Math and the Non-Traditional Learner (A Proposed Course Design).*

With respect to pre-algebra taught to non-traditional learners in non-traditional learning environments, the daunting task facing educators is transforming students that are considered "non college material" into focused adult learners spirited on to complete their educational goals. The presumption here is that these students have the potential to make the transition to college algebra and then onto other analytically focused courses (finance, accounting, economics, statistics, etc.). To achieve these ends, a revamped remedial mathematical course will have to be developed and introduced. Given that the students that enroll into the remedial mathematics course severely lack the most basic mathematical skills, these students do not benefit from the usual mass teaching methods and are more likely to become disenchanted with the program and abandon their educational goals. This presentation and subsequent paper will discuss the methodology used to support learning objectives for the remedial mathematics student in the non-traditional learning environment. Topics will include: Course Placement in the Curriculum Course Design (Iterative Process) Student Orientation Pre and post test design The Math Czar (Received September 22, 2010)

1067-D1-1938 **G Michael Guy*** (michael@gmichaelguy.com), Queensborough Community College, CUNY, Department of Mathematics & Computer Science, 222-05 56th Ave Rm S-245, Bayside, NY 11364. *Accelerated WARM UPS: Doing more with less time used differently. Remedial Arithmetic in as Little as 20 hours.*

The economics of cost cutting paired with increased enrollment requires doing more with less. Traditionally our students have taken 45-60 hrs of lecture based remedial arithmetic. The Accelerated WARMUPS (Workshop Approach to Remedial Mathematics Using Problem Solving) program is 20 hrs of students spending almost the entire time solving problems encompassing the entire curriculum. This immediately engages students in the problem solving process they will need in college level math.

A recent semester's statistics indicate this program is successful. The pass rate, determined by a standardized test, of the traditional course was 38% with 30% withdrawal. The WARMUPS had a pass rate of 62% with only 20% withdrawal. The available data also indicate that students enrolled in WARMUPS may have a slightly higher success in the remedial algebra class that follows than those in the traditional class.

Since these classes meet only 20 hours, we offer 3 sessions per semester. One instructor can teach 60 students rather than 28.

I will explain the logistics and support needed for this model and indicate future directions for improvement.

This study is funded in part by an Improving Math Learning Grant from the City University of New York.
Joint with J.Cornick, R.Holt and A.Russell. (Received September 22, 2010)

1067-D1-2023 **Kathryn T Ernie*** (kathryn.t.ernie@uwrf.edu), University of Wisconsin - River Falls, 206E North Hall, River Falls, WI 54022, and **Erick B Hofacker** and **Sherrie Serros**. *Improving the Transition from High School to College Mathematics.*

During the 2009-10 school year, with funding by the University of Wisconsin System, we developed a project to increase the percentage of college freshman from Wisconsin High Schools ready to enter credit-granting courses in mathematics in the UW-System. All incoming freshman in the system take a common placement exam to determine where they will be placed in mathematics at each institution.

To meet the goals of the grant, we conducted multiple workshops with 16 high school math teachers in our area to discuss the transition for students from high school to collegiate mathematics. During the course of our workshops, mathematical threshold concepts which impede student progress were identified by the group.

Groups of teachers then engaged in Lesson Studies to focus on identified threshold concepts. These high school teachers also had their students take an early math placement exam to determine and address areas in math where students may have difficulty in the future.

The project was evaluated by an outside evaluator. Assessment designs included initial perceptions and practices of the teachers, curriculum strengths and weaknesses, student readiness for the placement exam, and other qualitative data to evaluate the usefulness of the program. (Received September 22, 2010)

1067-D1-2100 **Clyde L. Greeno*** (greeno@malei.org), The MALEI Institute, P.O. Box 54845, Tulsa, OK. *The Mathematical Fitness Center: An Alternative Program for Salvaging Mathematically Suppressed Students and Pre-students, STEM and Otherwise.* Preliminary report.

As a portal into college-level mathematics, the national program for developmental education has been woefully under-productive. A major cause is the constraints imposed by traditionally structured, time-locked, class-paced, swim or sink semester/quarter courses into which students are placed/misplaced by superficial tests and by misleading transcripts. Those constraints minimize instructors' opportunities to make the subject matter commonsensible to the students themselves, or to develop their mathematical thinking/learning powers as needed for genuine success with future courses. Those constraints also greatly hamper faculty efforts to progressively improve their instructional programs.

Also, the present program assists only persons who are enrolled in college programs: not the high-potential adults who would attend college, were it not for their scholastic experiences with curricular mathematics.

Now being developed is a "mathematical fitness center" alternative to the traditionally structured developmental program . . . open also to math suppressed adults who are not yet enrolled in college. It is to be a model for how colleges might productively overhaul their developmental programs, while also providing an invaluable service for their respective communities. (Received September 22, 2010)

1067-D1-2217 **Michael B. Scott*** (mscott@csumb.edu), California State University, Monterey Bay, Mathematics and Statistics Department, 100 Campus Center, Seaside, CA 93955, and **Alysia Walther**. *The Effectiveness of Intensive Workshops in Developmental Mathematics.*

With growing enrollments and shrinking funds, many universities are encouraging students needing developmental mathematics to satisfy this requirement in the summer before they begin their freshman year. California State University, Monterey Bay instituted a summer and winter intensive workshops for developmental mathematics students close to readiness. In the California State University system the stakes are high for students in developmental courses. The developmental requirement must be completed within one year from the date of initial enrollment and the winter workshop provides an additional pathway to meet the requirement. The purpose of this session is to discuss how students who met developmental requirement through the intensive workshops have performed in later university level mathematics courses. This includes students with math-intensive majors and comparisons with students who met the requirement through our standard developmental course sequence. (Received September 22, 2010)

Effective Teaching of Upper Level Mathematics to Secondary Education Mathematics Majors

1067-E1-305 **Mark A Miller*** (millerr@marietta.edu), Department of Math, Computing & Info Systems, Marietta College, Marietta, OH 45750. *Geometry then and now: Making room for Euclid in the 21st century mathematics curriculum.*

For centuries, Euclid's *Elements* served as a standard mathematics text. While much has changed in mathematics education since the days of Euclid, an argument can be made that Euclid still has a great deal to offer high school students. In this talk, we will consider ways to incorporate ideas from Euclid's *Elements* into upper level courses for students planning to teach at the secondary level. We will also consider some historical, cultural, philosophical, and material that a study of Euclid may provide for our students. (Received August 18, 2010)

1067-E1-731 **Kristin A. Camenga*** (kristin.camenga@houghton.edu), One Willard Ave, Houghton, NY 14744, and **Rebekah Yates** (rebekah.yates@houghton.edu), One Willard Ave, Houghton, NY 14744. *Helping Pre-service Teachers Recognize Continuity in the Secondary Curriculum.*

Real analysis is a course that secondary math education students tend to find disconnected from the content they will be teaching. Secondary math content includes many subtle uses of continuity, a major topic in undergraduate real analysis. To help pre-service teachers apply these ideas to what they will teach, we explored several of these examples with future teachers who have completed real analysis. We will discuss the materials used as well as students' responses. (Received September 14, 2010)

1067-E1-830 **Sandra Fillebrown*** (sfillebr@sju.edu), Saint Joseph's University, Department of Mathematics, 5600 City Avenue, Philadelphia, PA 19131. *Making Connections in Real Analysis for Students Interested in Secondary Mathematics Education.*

As in many colleges and universities, students at Saint Joseph's University that are interested in a career as secondary school mathematics teachers take the same set of mathematics classes as any mathematics major. Thus, our upper level mathematics course include future high school teachers as well as students intending to go on to graduate school. The students interested in teaching wonder why they need to take some of these courses, complaining that they will never "use this stuff" when they are teachers. We tell them that they need to see the "bigger picture" and that in order to really understand what is going on they need to take advanced courses such as Modern Algebra and Real Analysis.

However, we rarely take the time to make the connections between what they are learning in these courses and what they will be teaching in high school. This semester, in Real Analysis, I am trying to make these connections more explicit by including questions on each weekly problem set that investigate some high school topic related to what we are currently studying. This talk will present the questions from the assignments and student responses, as well as findings about whether the students interested in mathematics education found them useful. (Received September 15, 2010)

1067-E1-944 **Scott S Searcy*** (searcys@waldorf.edu), 106 South Sixth St, Forest City, IA 50436, and **Jeffrey B Biessman** (biessmanj@waldorf.edu), 10‘, Forest City, IA 50436. *Changing Their Culture: A Multi-Faceted Approach to Improving Math Secondary Education Major's View of Mathematics.*

In this talk we will outline several techniques designed to change the outlook of Secondary Education students enrolled in a licensure program in Mathematics. Topics discussed will include, use of a bridge course, design and content of the bridge course, liaison with the Education department, classroom structure and environment and the use of positive peer mentoring within the program. This comprehensive approach can be successful in reducing attrition by alleviating each student's fear of abstract mathematics. (Received September 16, 2010)

1067-E1-1147 **Jennifer A Bergner*** (jabergner@salisbury.edu), 1101 Camden Ave., Dept. of Math/CS, Salisbury, MD 21804. *Experiencing the history of mathematics in a capstone course for prospective teachers.* Preliminary report.

In an effort to emphasize the importance that the historical development of a concept plays in mathematics I integrate math history throughout the senior-level capstone course for our secondary education math majors. In order to engage the prospective teachers in researching how the "past" can influence the mathematical topics they will be teaching in their secondary school classrooms, I have designed a mathematics history project. The project involves researching a mathematician and an interesting mathematical contribution he or she made. Students also investigate what was happening in the world culturally and mathematically at the time. The only restrictions are that each student must choose a unique mathematician and that a range of subjects (algebra to statistics) must be covered by the classes' choices. They then write a paper, present their work during a class session that is open to the mathematics department, and have their paper and presentation critiqued by their peers. Each student reviews the presentations. They are assessed for their presentations as well as their reviews. I will share how this assignment worked in my classroom. (Received September 19, 2010)

1067-E1-1240 **Talitha M. Washington*** (tw65@evansville.edu), 1800 Lincoln Ave., Evansville, IN 47722. *Revisiting College Geometry: Making it Relevant for Math, Math Education and Elementary Education Majors.*

Most universities offer a course in geometry that includes discussions of incidence, neutral, Euclidean and hyperbolic geometries via an axiomatic approach. In this talk, we discuss challenges of making this course relevant to students that major in areas such as mathematics, secondary education, and elementary education. We also offer some strategies that make the learning environment stimulating to all majors. (Received September 20, 2010)

1067-E1-1244 **Ockle E Johnson*** (ojohnson@keene.edu), Mathematics Department, Keene State College, Keene, NH 03431. *The Calculus Book: A Text for Analysis?* Preliminary report.

Despite continually emphasizing to them the obvious connections, my students often experienced Introductory Analysis as foreign and remote from Calculus or anything else they would teach in high school. By using their calculus book as an analysis text, students actually read the calculus book—some for the very first time—and discovered in its chapters, appendices, and higher-numbered exercises the basic elements of analysis. I will outline the results of this approach and some interesting consequences including a more natural, organic development of uniform continuity, compactness, and the Heine-Borel Theorem and a hybrid algebra/analysis course focusing on the algebraic structures and analytic properties of number systems and polynomials. (Received September 20, 2010)

1067-E1-1249 **Vesna Kilibarda*** (vkilibar@iun.edu), Indiana University Northwest, Department of Mathematics and Actuarial Sci., 3400 Broadway, Gary, IN 46408. *Geometry for Prospective Mathematics Teachers.*

We teach a geometry course for prospective mathematics teachers pursuing undergraduate Secondary Education and graduate Transition-to-Teaching programs. Selection of student learning goals, appropriate activities and projects, assessment items, and use of technology are all guided by NCTM standards and principles. We created effective classroom activities using dynamic software that connects transformational and analytic geometry. In developing synthetic Euclidian geometry we emphasize a historic perspective. To investigate non-Euclidean geometries we use Lenart spheres and explore the Poincare disk model of a hyperbolic plane with Java applets. Two-part examinations (take-home and in-class) allow for in-depth problem solving. Students use the Drop Boxes in our course management system to deposit homework and exams with all constructions done with dynamic software. Students spend a class period with a reference librarian who helps them research a topic in depth that they have chosen for the group project. They are able to share drafts of group projects and presentations among group members and with the instructor. The whole class is involved in grading these projects using appropriate rubrics. Examples of class activities and students' projects will be shown in the paper. (Received September 20, 2010)

1067-E1-1466 **Kenneth J Bernard*** (kbernard@vsu.edu), Dr. Kenneth J Bernard, Dept of Math & Computer Science, PO Box 9068, Petersburg, VA 23806. *History of Mathematics for Prospective Secondary Teachers.*

Although several mathematics courses may include some material on the history and development of mathematical topics, many students preparing for a career in secondary mathematics teaching have little background in the subject. At Virginia State University a course in the History of Mathematics is required for these students. The course is becoming a writing intensive course for majors where students complete two historical topics presentations and a paper on the life and works of a famous mathematician as part of the course requirements. An overview of the student work will be shared with specific excerpts available for discussion and review. (Received September 21, 2010)

1067-E1-1482 **Sharon S. Emerson-Stonnell*** (emersonstonnellss@longwood.edu), Mathematics Department, Longwood University, Ruffner 333, Farmville, VA 23909. *"Practicing What We Preach" in Multivariable Calculus.* Preliminary report.

NCTM has six principles and ten standards for mathematics in grades 9-12. This presentation will address how two of the principles, curriculum and learning, and three of the standards, reasoning and proof, communication, and connections, can be modeled in multivariable calculus. Longwood University offers a four-credit class that is offered in a lecture and class discussion format three days a week and lab format one day a week. The course is designed primarily for mathematics, physics, and pre-engineering majors. The three-dimensional geometry taught in the course allows a unique opportunity to connect to the high school topics of measurement and conic sections. Through labs developed for multivariable calculus, students' experiences in high school are used as an introduction to those same concepts in three-dimensions and higher. Groups of are encouraged to look for patterns, determine whether or not the pattern always holds, and support their thoughts through mathematical reasoning. This presentation will share some of these labs and how they are used throughout multivariable calculus. (Received September 21, 2010)

1067-E1-1674 **Sarah K. Bleiler*** (sbleiler@mail.usf.edu), University of South Florida, College of education/Secondary Education, 4202 E. Fowler Ave.-Stop EDU 105, Tampa, FL 33620-5650, **Gladis Kersaint** (kersaint@usf.edu), University of South Florida, College of Education/Secondary Education, 4202 E. Fowler Ave.- Stop EDU 105, Tampa, FL 33620-5650, and **Milé Krajcevski** (mile@mail.usf.edu), University of South Florida, Department of Mathematics and Statistics, 4202 E. Fowler Ave.- PHY 114, Tampa, FL 33620-5700. *Differing views on assessment: Two instructors' strategies for modeling assessment techniques for prospective secondary mathematics teachers in an upper level team-taught geometry course.* Preliminary report.

In this case study, two instructors (a mathematician and a mathematics educator) worked together to collaboratively teach a geometry course for prospective secondary level mathematics teachers. Data collected in the form of classroom observation field notes and transcripts from audio-recorded planning sessions indicated that the two instructors held different perspectives on the purposes and procedures of assessment. In this session, several of the key differences related to assessment that arose between the instructors will be discussed. The instructors agreed to use a proof scoring rubric (adapted from http://www.exemplars.com/resources/rubrics/nctm.html) as a way to maintain consistency in grading as well as to model assessment strategies for prospective secondary mathematics teachers. Examples of how students' proofs were assessed using the rubric will be provided, and a strategy for helping students to think critically about their own responses will be discussed. (Received September 21, 2010)

1067-E1-1822 **Amy Mihnea*** (amihnea@fau.edu). *Research-Based Methods for Improving Learning and Assessment.*

We present some recommendations for instructors on how to organize their instructional time, and for students on how to structure their use of study time, in order to promote faster learning and better retention of knowledge. We then focus on assessment and present some sources of invalidity that should be taken into account when designing experiments. Other recommendations, specific to mathematics courses, are given, based on experiments that have been implemented in the last 25 years. (Received September 21, 2010)

1067-E1-1830 **Feryal Alayont*** (alayontf@gvsu.edu), GVSU Mathematics Department, 1 Campus Dr., Allendale, MI 49401. *Minding the Pre-service Teacher Students in a Discrete Mathematics Class.* Preliminary report.

Discrete mathematics at my institution is a proof-based course with a significant graph theory component. The course is required of all education emphasis mathematics majors (pre-service elementary or secondary teachers) and, as a result, these students make up a majority of the students in the course. While teaching the course, I take into account this specific audience in many ways. I employ a modified Moore method for teaching, where students solve problems on the board and as part of in-class activities, and assign research projects appropriate for this audience. Written and verbal communication for different types of audiences, and conjecturing is also strongly emphasized. In this talk, I will describe and review these approaches in detail along with student responses to them. (Received September 21, 2010)

1067-E1-2161 **Kevin Hartshorn*** (hartshorn@math.moravian.edu), Department of Mathematics & Computer Science, 1200 Main St., Bethlehem, PA 18018. *Lines and circles: A range of viewpoints.* Preliminary report.

To help develop geometric thinking and strong problem-solving skills, teachers need to have an active understanding of alternative approaches to geometric problems. I will discuss methods used in my college geometry course, as well as in teacher workshops, to take some fundamental geometry problems and study them from several viewpoints. I will show how just a few basic problems from high school geometry can be explored through the use of manipulatives, cooperative work, technology tools, and non-euclidean geometries. (Received September 22, 2010)

1067-E1-2179 **Elizabeth A Burroughs*** (burrough@math.montana.edu), PO Box 172400, Department of Mathematical Sciences, Bozeman, MT 59717. *Pre-Algebra Connections with the Chinese Remainder Theorem.*

A number theory course is generally required as part of a secondary mathematics teacher preparation program. NCTM's Principles and Standards for School Mathematics calls for instruction enabling students in grades 6–8 to "use factors, multiples, prime factorization, and relatively prime numbers to solve problems," and for students in grades 9–12 to "use number theory arguments to justify relationships involving whole numbers"(NCTM, 2000). The Conference Board of the Mathematical Sciences, in The Mathematical Education of Teachers, calls for prospective middle school teachers to "understand and be able to explain fundamental ideas of number theory as they apply to middle school mathematics" (CBMS, 2001). The Chinese Remainder Theorem is a number theory topic that has connections to the mathematics of a pre-algebra classroom. This paper describes a sequence of problems that can be used in educating pre-service mathematics teachers about the Chinese Remainder Theorem by investigating connections to important ideas in a pre-algebra curriculum. (Received September 22, 2010)

1067-E1-2410 **Joy Moore*** (moorej12@xavier.edu), 3800 Victory Parkway, 112 Hinkle Hall, Mathematics Department, Cincinati, OH 45207-4441. *The Impact of the Moore Method on Secondary Mathematics Education Majors.* Preliminary report.

A modified Moore Method is pedagogically employed in a real analysis course that is a program requirement for secondary mathematics education majors. This qualitative study investigates the impact of that method on the learning experiences for secondary mathematics education majors. The study includes interviews with students, class observations, and reflective journal notes from the instructor. Research questions include: What effect has the modified Moore method of instruction had on student learning? Is student learning impacted beyond the real analysis course? For secondary mathematics education majors, data suggests that the method provides the types of learning experiences that reinforce the types of learning opportunities we want our teachers to provide for their students. Data also suggests that the method aligns with NCTM recommendations for problem solving, reasoning and proof, and communication. The implication of this result is that secondary math education majors in particular need to experience the Moore Method in their undergraduate mathematics education. (Received September 23, 2010)

Fostering, Supporting, and Propagating Math Circles for Students and Teachers

1067-F1-973 **Jeffery T. McLean*** (jtmclean@stthomas.edu), 1746 Wellesley Ave., Saint Paul, MN 55105. *Gnomons at the Teacher Circle.*

A report on the session on gnomons at this summer's teaching circle for middle school teachers. A review of content with an emphasis on the porojects and group work designed to lead to classroom units on geometry. (Received September 17, 2010)

1067-F1-1363 **Nathan A. Carlson*** (ncarlson@callutheran.edu), 60 W. Olsen Rd, MC 3750, Thousand Oaks, CA 91360. *A Tale of Two Circles.*

In 2007 I helped co-found the Tucson Teachers' Circle at the U. of Arizona along with Virginia Bohme. In terms of participation and feedback, the TTC has been a great success and is held in high regard in the local school districts. Being in a large metropolitan area with many middle and high schools, the TTC has its particular advantages as well as challenges. I'm now at Cal. Lutheran University in Thousand Oaks, CA and am in the process of co-founding the T.O. Teachers' Circle with Dr. Hala King. Thousand Oaks is a smaller community with fewer local schools, and CLU is a smaller university with less resources. This then gives the T.O. Circle its own particular set of advantages and challenges, which has become evident even in its creation stage. Further contrasts between the two circles will be discussed. (Received September 20, 2010)

1067-F1-1630 **James S Tanton*** (jamestanton@stmarksschool.org), 25 Marlboro Rd, Southborough, MA 01772. *A Sampling of Successful Math Circle Topics*

The title says it all! In this presentation we shall examine and explore a number of topic ideas that have proved successful in the math circle experience for youngsters aged 9 to 18. (Received September 21, 2010)

1067-F1-1638 **Paul Zeitz*** (zeitz@usfca.edu), Mathematics Department, University of San Francisco, 2130 Fulton St, San Francisco, CA 94117-1080. *The San Francisco Math Circle: An experiment in providing mathematical enrichment to "unenriched" students.*

Most mathematical circles, through no fault of their own, tend to serve as enrichment opportunities for "already enriched" students. Programs that target other audiences require special resources and planning.

The San Francisco Math Circle (SFMC), which began its 6th year in September 2010, is a program that specifically targets students from underrepresented populations, as well as their teachers. It serves over a hundred students in grades 6–12 and over a dozen teachers in three different locations. Instructors include school teachers, college students, grad students, and professional mathematicians.

As a moderately "mature" program, the experiences of the SFMC may prove instructive to others contemplating similar programs. Issues we will discuss are: funding, incentives, logistics, resources, and challenges. (Received September 21, 2010)

1067-F1-1646 **Paul Zeitz*** (zeitz@usfca.edu), Mathematics Department, University of San Francisco, 2130 Fulton St, San Francisco, CA 94117-1080. *San Francisco Math Circle: Examples of good "small group" mathematical activities.*

The San Francisco Math Circle operates at three different locations, each with its own educational culture. The location at Mission High School, now in its 4th year, inherited a culture of "small-group learning" which presents unusual challenges to more traditional instructors. We will discuss some of these challenges, as well as activities that work well in this setting. (Received September 21, 2010)

1067-F1-1658 **Sam Vandervelde*** (svandervelde@stlawu.edu), Dept of Math, CS and Stats, St. Lawrence University, 23 Romoda Drive, Canton, NY 13617. *Yielding the Floor: Student-Driven Math Circles.*

According to The National Association of Math Circles, one of the intended goals of a circle is to provide a setting that encourages students to become passionate about mathematics. But this goal can be elusive—we are all familiar with the experience of presenting material that we find fascinating, only to be slightly disappointed with the lack of appreciation on the part of our audience. In this talk we will discuss strategies for enabling students to contribute, in a meaningful way, to the development of a mathematical idea without setting the circle adrift. We will also examine other factors, such as room size or choice of topics, which can either promote or inhibit the desired setting. Finally, we will present a variety of topics and problems that are well-suited to fostering passion for mathematics. (Received September 21, 2010)

1067-F1-1903 **Silva Chang*** (silva.chang@colorado.edu), Department of Applied Mathematics, 526 UCB, University of Colorado at Boulder, Boulder, CO 80309-0526, and **Anne M Dougherty**. *Sophie Math: a Math Circle Program for Girls.*

Two years ago the Colorado Math Circle created a new program called Sophie Math—named after the mathematician Sophie Germain—to increase the participation of girls in math circle activities. We designed a curriculum for a weeklong summer workshop for middle school girls that emphasized hands-on activities and collaborative problem solving. In summer 2009 the first Sophie Math workshop attracted dozens of young girls from around the state who had never participated in extracurricular math before. In summer 2010 the workshop was offered again, along with a Sophie Mathematica programming workshop for high school girls. As a result of these summer programs, the number of female students now attending regular math circle meetings has increased significantly. We will discuss the setup of the Sophie Math workshops, describe the curriculum, and provide samples of workshop activities. (Received September 22, 2010)

1067-F1-2003 **Philip B Yasskin*** (yasskin@math.tamu.edu), Department of Mathematics, Texas A&M University, 3368 TAMU, College Station, TX 77843-3368. *Texas A&M Summer Educational Enrichment (SEE-Math) for Middle School Students: Organization and Technology.*

For the last nine year, the Texas A&M Math Dept has conducted a Summer Educational Enrichment Program (SEE-Math) for gifted middle school students entering the 6th, 7th or 8th grade. Last year, the instruction was provided by 16 faculty with the help of 8 undergrad students, and 7 high school students. From 81 applicants, we accepted 44 students based on their ability and interest in math and science as reported by their teachers.

The curriculum consists of a collection of activities which do not appear in the usual grade school curriculum. Many of the activities are organized so that the students recognize patterns, make conjectures and either prove or disprove them. These include Platonic solids, Euler numbers, toothpick puzzles, Pythagorean theorem, map coloring, logic puzzles, Mobius strips and graph theory. Other activities teach applicable computation, such as computer animations, geometric constructions, pigeon hole principle, Venn diagrams, cryptography, probability, and search ranking algorithms.

More information is available at http://www.math.tamu.edu/outreach/SEE-Math/

The focus of this talk will be on the organization of the program and the activities which make use of computer technology: computer animations, cryptography and search ranking algorithms. (Received September 22, 2010)

1067-F1-2067 **Diana White*** (diana.white@ucdenver.edu), Mathematical & Statistical Sciences, University of Colorado Denver, Campus Box 170, P.O. Box 173364, Denver, CO 80233. *Math Teachers' Circles - Impacting Teachers' Mathematical Knowledge for Teaching.*

As Math Teachers' Circles (MTCs) continue to spread across the country, a growing community of scholars is interested in researching their impact. This talk describes the results of a study from Summer 2010 in which MTC participants showed statistically significant gains on an instrument measuring their Mathematical Knowledge for Teaching. The study included approximately 50 teachers from three intensive summer workshops. The teachers took two subsections of the Learning Mathematics for Teaching (LMT) assessment developed at the University of Michigan. In previous research, higher LMT scores have been linked with a variety of positive outcomes, including presenting richer mathematics in the classroom and higher student achievement scores. After just one intensive week of participating in MTC activities, teachers' scores increased significantly on both subsections of the LMT assessment that they took. This result is novel given that the intensive workshops focused on problem solving and the mathematical process in general rather than on any specific content area. (Received September 22, 2010)

1067-F1-2107 **Diana White** and **Brianna Donaldson*** (brianna@aimath.org), 360 Portage Ave., Palo Alto, CA 94306. *How Do Math Teachers' Circles Affect Teachers? Themes from Teacher Surveys.*

This talk focuses on qualitative evidence of the effects of Math Teachers' Circle (MTC) participation on teachers' mathematical confidence, knowledge, and classroom practice. We describe common themes that emerge from an analysis of teacher surveys from three intensive MTC workshops held in Summer 2010. We also present preliminary results from a survey of long-term participants in MTCs throughout the country, focusing on how MTC participation has affected what these teachers do in the classroom. Finally, we discuss some future directions for research and evaluation of the impact of MTCs. (Received September 22, 2010)

1067-F1-2150 **Angela Hodge*** (Angela.Hodge@ndsu.edu). *Obtaining funding for a Math Teachers' Circle: One group's journey.*

Math Teacher's Circles: merely a year ago, I thought this was just another good idea that worked for others, but was not something that an untenured faculty member at a rural university would even have a chance at starting. I quickly learned that this was not the case. Math Circles are actually a great way for faculty at all levels to reach out into the community and at the same time study how people learn the mathematics of problem solving. How did I take the idea of a Math Circle and turn it into a reality? The journey started with attending a Math Circle workshop to learn more about what was involved in initiating a Math Circle. This experience evolved as our group began to realize that a Math Circle was not out of our reach, and would in fact be a valuable way to promote mathematics throughout the region. We successfully wrote a grant that secured funding for a two-year Math-Science Partnership that will enable us set the groundwork for a Math Circle. In this session, I will share what I learned from the grant writing process and how other groups can help fund their own Math Circles. Information will also be provided on the plans for our Math Circle that helped sell the idea to funding agencies, school districts, and universities. (Received September 22, 2010)

1067-F1-2188 **Ted Theodosopoulos*** (ttheodosopoulos@saintannsny.org), 60 Wyckoff Street, Brooklyn, NY 11201. *Problem solving paradigms for mathematical research.* Preliminary report.

In this talk I describe the ways I use a math circle type problem solving seminar to inspire and cultivate a mathematical research culture. Examples are described that illustrate the seamless transition from problems through conjectures to research projects, stemming from our sessions on calculus and differential equations, geometric inversion, point set topology, vector algebra, combinatorial geometry and cellular automata. (Received September 22, 2010)

1067-F1-2251 **Tatiana Shubin*** (shubin@math.sjsu.edu), San Jose State University, Department of Mathematics, San Jose, CA 95192-0103. *Math Circles Library.* Preliminary report.

Success or failure of a math circle depends to a large degree on topics and problems chosen by the leaders. In this talk we will review and discuss a variety of available materials from general problem books and web sites to some special projects such as AMS MSRI Mathematical Circles Library. (Received September 22, 2010)

1067-F1-2290 **Manda Riehl*** (riehlar@uwec.edu), 508 Hibbard Humanities Hall, 105 Garfield Ave, Eau Claire, WI 54702-4004. *Creating a Math Circle for Underrepresented Minority Students.*

We focus on keys for successfully creating a semi-formal mathematics community built around underrepresented minority students. We discuss our experience creating a math circle for Hmong high school students, a chronically underserved and underrepresented community in mathematics. Our program, called OOMPH (Opportunities for Outstanding Mathematics Performance for Hmong Students), pairs competition-level mathematics, both national and local, with material that shows the hidden mathematics in Hmong culture. We discuss strategies for: minority participant recruitment, cultural conflicts, effective communication, finding resources, assessing effectiveness, and sustaining motivation. (Received September 22, 2010)

1067-F1-2353 **Japheth Wood*** (jwood@bard.edu), Bard MAT Program, PO Box 5000, Annandale-on-Hudson, NY 12504. *Math Circles along the Hudson River: from New York City to Albany.*

Over the last ten years, Math Circles, including the New York Math Circle, the Bard Math Circle and the Albany Area Math Circle, have established themselves in cities along the Hudson River. This talk is an overview of how these efforts have interacted and cooperated to provide high quality math enrichment to students and teachers, and how they are helping other math circles get started. (Received September 22, 2010)

1067-F1-2394 **Dave Auckly*** (auckly@msri.org), 17 Gauss Way, Berkeley, CA 94720. *Resources for math circles.*

This presentation will describe many of the resources that are available to people running or wishing to run a math circle. These include two national organizations, several training workshops, various publications and funding sources. (Received September 23, 2010)

1067-F1-2399 **Brandy S Wiegers*** (brandy@msri.org), 17 Guass Way, Berkeley, CA 94720, and **Yuan-Juang Yvonne Lai** (yxl@umich.edu). *San Francisco Math Circle (SFMC) Mathematics and Community Attitudes Survey and Evaluation Tool.* Preliminary report.

San Francisco Math Circle (SFMC), an after-school program for teachers and precollege students, strives to increase the quality and quantity of students who become mathematics educators and researchers, or who simply love and use mathematics in their studies, work and daily activities. SFMC's unique model both relies upon and supports its teacher participants. Our teachers transport and recruit student participants. In turn, we provide a unique professional development opportunity and supportive mathematical pedagogical environment.

Our objective at SFMC is to develop a safe mathematical community for all participating students and teachers. To measure our effectiveness at achieving this community and of changing student participants' mathematical attitudes we have created a strategic Math Circle participant survey. We gave the initial survey to Spring 2010 SFMC students. The Summer was used to review survey results and survey design. The resulting survey upgrades were administered in Fall 2010 and will be administered again in Spring 2011 with specific focus given to changes in individual student participant self assessment of achievement/ motivation as a result of Math Circle participation. We look forward to sharing our survey tool and initial results at the meeting. (Received September 23, 2010)

Getting Students Involved in Writing Proofs

1067-G1-309 **Bernd S. W. Schroeder*** (schroder@coes.LaTech.edu), Program of Mathematics and Statistics, Louisiana Tech University, Ruston, LA 71272. *(How) Can We Teach Proofs? A Classical Approach.*

We will briefly make a case that the answer to "Can we teach proofs?" is "yes" as well as "no." Subsequently, we will outline a classical approach that involves students in proof writing by starting with natural questions, such as, "Why can we not divide by 0?" or "Why are financial internet transcations secure?" These questions lead to the construction of the familiar number systems. We will also address relevant questions that should be asked before teaching a first or early proof class, as well as mathematical and "human resource" aspects of fostering proof writing abilities. (Received August 19, 2010)

1067-G1-456 **Mary K Flagg*** (mflagg@math.uh.edu), University of Houston, Department of Mathemics, 651 PGH, Mail Code 3008, Houston, TX 77204-3008. *A Group Project.*

The two earliest introduction to proof classes offered at the University of Houston are the junior level introduction to abstract algebra and intermediate analysis. I have been fortunate to teach several sections of the abstract algebra class over the last two years. My trademark is an interactive test review. In this talk I will explain how I get 95% of the class involved in working problems in small groups and presenting their answers to the class. I will share the insights students have gained from this experience. I will also report on objective evidence of this method's success. For example, in the spring of 2010 the average test score was ten points higher than the average score on homework turned in before the review. (Received September 04, 2010)

1067-G1-668 **Firas Y Hindeleh*** (hindelef@gvsu.edu), 1 Campus Dr., Allendale, MI 49401. *Using Bluetooth Technology in a Proof Writing Course.* Preliminary report.

In this talk, I share my experience in bringing the bluetooth technology into my math classes. In particular I will focus on using this technology in my introductory proof-writing course to engage students in an active peer review discussion. (Received September 13, 2010)

1067-G1-911 **Mindy Beth Capaldi*** (mindy.capaldi@valpo.edu), 1900 Chapel Dr., Valparaiso, IN 46383. *Teaching Proofs in Abstract Algebra: How important are proof structure, group work, and student presentations?*

In addition to learning the material in Abstract Algebra, one of the most vital aspects of the class is the enhancement of the students' proof-writing abilities. Students may enter the class from different proof-writing backgrounds with varying levels of confidence about their proofs. In this class, I investigated the importance of teaching proofs with an emphasis on rigorous structure, as well as the benefits/drawbacks of assigning proofs as group work to be presented to the class by a group member. Goals included increasing student self and peer assessment of proof logic and flow, and reduction of proof memorization in favor of direct involvement. In this presentation, I discuss the results as evaluated through grade assessment and student feedback. (Received September 16, 2010)

1067-G1-1100 **Jennifer A Bergner*** (jabergner@salisbury.edu), Department of Math/CS, 1101 Camden Ave., Salisbury, MD 21804. *Engaging abstract algebra students in the craft of proof writing.* Preliminary report.

In order to encourage students in both the content and craft of proof writing in abstract mathematics I have engaged 3 semesters of my abstract algebra students in a proof writing/critiquing cycle. In each section of material, students are assigned both a proof to write and a proof to edit/critique. The proof writer provides their editor and me with their proof. The editor then reviews the proof along the dimensions of content, clarity and craft and provides both the writer and me with the edited proof. I make further comments, turn the proof back to the writer and encourage them to edit their proof accordingly. The proof writer resubmits their final proof for a grade. I have various ways of assessing the whole process that helps guarantee student buy-in. I have found that my students rise to the challenge of crafting a proof that is to be read and evaluated by their peers. In this presentation I will share my approach, assessment strategies and collected evidence of student success with reading, writing, and editing proofs. (Received September 18, 2010)

1067-G1-1107 **Minah Oh*** (ohmx@jmu.edu), Department of Mathematics and Statistics, James Madison University, 305 Roop Hall, MSC 1911, Harrisonburg, VA 22807. *Introducing Proofs to Calculus Students.*

In this talk, I will talk about how to introduce proofs to Calculus 1 students. To teach Calculus students how to write rigorous mathematical proofs may be painful and sometimes unnecessary. It is surprising, however, how these students can get used to writing proofs when they do so regularly as a group. Throughout the semester, the students worked in groups once a week to prove important results in Calculus following a worksheet which provided instructions on how to prove the result. I will report the progress the students made throughout the semester while the worksheet gradually provided less instructions each week. The worksheets and the students' proofs will be presented. (Received September 18, 2010)

1067-G1-1579 **Xuan Hien Nguyen*** (xhnguyen@math.ksu.edu) and **Andrew Bennett**. *On peer grading to improve proof writing.*

The process of writing a proof is two-fold: first the proof has to be correct, then edited for clarity. In a geometry course for mathematics and secondary education majors, we use a modified Moore method to handle the first step. To help students write clearer proofs, we ask them to grade their own midterm, as well as the exams of two classmates. The assignment requires students to assess the correctness of a proof, recognize possible confusion, and remove unnecessary steps. Students are graded not only on their presentations and exams, but also on their grading. With data collected over multiple semesters, we discuss how helping students become better editors improves their proof writing skills. (Received September 21, 2010)

1067-G1-1757 **Sam Vandervelde*** (svandervelde@stlawu.edu), Dept of Math, CS and Stats, St. Lawrence University, 23 Romoda Drive, Canton, NY 13617. *Students of MATH 341, Advances in Number Theory, **1** (2010), 1–30.*

For professional mathematicians, one of the principle purposes for crafting carefully written proofs is to convey to others new mathematical results and to establish their validity. In short, we publish papers in journals. However, for the most part undergraduates are completely unfamiliar with this motivation and context for writing proofs. In this talk I will describe an unexpectedly sucessful component to a recent Number Theory Course based on these observations. Students engaged in investigating and proving theorems, wrote two-page papers based on their results, "submitted" them to our journal *Advances in Number Theory*, refereed one another's papers, and finally resubmitted their revised articles. I will relate the elements of this project that contributed to its success and share how it impacted students' perception of proof composition. Hard copies of the self-published issue produced by the class will be available for perusal. (Received September 21, 2010)

1067-G1-2131 **Shannon R. Lockard*** (slockard@bridgew.edu), Bridgewater State University, Bridgewater, MA 02325. *Using Clickers to Generate Discussion on Writing Proofs.*

Classroom response systems (clickers) are becoming increasingly widespread in college classrooms. Among other uses, clickers can encourage student participation and improve student engagement in lectures. In this talk, I will discuss my use of clickers in an Introduction to Proofs course. Clicker questions were used to generate discussions among the students. After an initial vote, students were instructed to discuss their answers in groups. A second vote led to either more group discussion or to class wide discussion. In particular, I will discuss my use of clickers to generate discussions on proof writing as well as student feedback on the use of clickers in this format. (Received September 22, 2010)

1067-G1-2168 **Nathan C Carter*** (ncarter@bentley.edu), 175 Forest St, Waltham, MA 02452, and **Kenneth G Monks**. *The Lurch Project: A word processor that checks your math.*

The Lurch Project is a new type of mathematical software, one designed not to compute answers for the user, but instead to check each step of the mathematics the user types into a word processor. Students find this immediate feedback valuable. This talk will briefly tour the current state of the project, and demonstrate how instructors can easily customize Lurch to the needs of their courses. Plans for the future of the project will also be mentioned, and an invitation for the mathematical community in general to become involved in shaping that future. More information is available at http://lurch.sourceforge.net. (Received September 22, 2010)

1067-G1-2239 **Kyeong Hah Roh*** (khroh@math.asu.edu), School of Mathematical and Statistical Scienc, Arizona State University, P.O. Box 871804, Tempe, AZ 85287-1804. *From Evaluating Proofs to Constructing Proofs.* Preliminary report.

The purpose of this study is to introduce an instructional sequence designed to help undergraduate students write proofs. Students in an introductory real analysis class participated in a semester long teaching experiment in spring 2010. Although some contents were provided by a traditional lecture style, instruction in the class was mainly given by an inquiry approach, in which students first worked together in small groups and later the whole class discussion followed. Within the group discussions, students were often asked to (1) evaluate if given (erroneous) arguments are legitimate as mathematical proofs; (2) complete a proof using given key ideas; (3)complete a proof using the given proof format; and finally (4) construct a proof without any instructional scaffold. To assess individual students' progress in proof writing, homework and exams were analyzed and task-based interviews were also conducted in the 7th and 15th weeks of the semester. From the data analysis reveals the improvement in individual students' proof writing as well as their comprehension of proofs. This presentation will address how the instructional sequence helped students enhance their ability in proof writing. (Received September 22, 2010)

1067-G1-2346 **Lesley W Wiglesworth*** (lesley.wiglesworth@centre.edu), 600 W. Walnut Street, Danville, KY 40422. *Successful Strategies for Improving the Proof Writing of Linear Algebra Students.*

Linear algebra is often one of the first courses in which students are required to understand exactly what a proof is and how to write one. Because so many students are intimidated by formal mathematical proofs, I have tried several methods to engage my linear algebra students in proof writing. In this talk, I will share my experiences with group proof writing activities, peer review, and a daily proof writing assignment, as well as provide student feedback. I will also discuss which methods have had the greatest positive impact on my students. (Received September 22, 2010)

1067-G1-2358 **Dana C. Ernst*** (dcernst@plymouth.edu), MSC 29, 17 High Street, Plymouth, NH 03264, and **Angela Hodge**. *Within ϵ of independence: An attempt to produce independent proof-writers via an IBL approach in a real analysis course.*

For three consecutive semesters, the speaker taught an introduction to proof course to both mathematics and mathematics education majors at a small state university. The first two iterations of the course were taught via a traditional lecture-based approach, where students only engaged in the process of proof while working on homework or exam problems. However, the third instance of the course was taught using an inquiry-based learning (IBL) approach with an emphasis on collaboration. When the speaker taught an abstract algebra course containing students from both styles of the introduction to proof course, anecdotal evidence suggested that the students taught via IBL were stronger proof-writers and more independent as learners than those introduced to proof in a lecture-style course. Inspired by the apparent effectiveness of IBL, the speaker chose to adopt this approach in his real analysis course and study it with a mathematics education specialist. In this talk, we will relay the speaker's approach to engaging students in the proof-writing process, present quantitative data supporting the effectiveness of a collaborative IBL approach, and present qualitative data describing student perception of knowledge acquisition with regards to proof in an upper-level mathematics course. (Received September 22, 2010)

Harnessing Mobile Communication Devices and Online Communication Tools for Mathematics Education

1067-H1-318 **Jason D Holland*** (hollandj@acu.edu), ACU Box 28012, Abilene, TX 79699. *Mobile Jumpstarts in a First Semester Calculus Course.* Preliminary report.

In the fall of 2010, every student at Abilene Christian University will be given their choice of either an iphone or an ipod touch. This will provide instructors with a unique opportunity to engage students using these devices. In this presentation, we will focus on the results of an experiment involving two sections of first semester calculus students. Students will be given daily questions called *jumpstarts*. These questions will be delivered on their mobile devices utilizing certain polling tools on the ACU website. We will give data regarding the impact on course objectives as well as qualitative feedback from the students. (Received August 20, 2010)

1067-H1-1336 **Jill E Jordan*** (jill.jordan@houghton.edu), Houghton College Department of Mathematics, 1 Willard Avenue, Houghton, NY 14744. *Blogging Together: Using a Class Blog to Enhance Learning in a Proof-Writing Cclass.*

Through the creation of a class blog and weekly blogging assignments, students in my introductory proof-writing class were given the opportunity to reflect on their class experiences and on their own personal growth as mathematicians. In addition, they were required to respond to classmates' blog entries, which helped students to learn from each other, and fostered a spirit of cooperation within the class. In this talk I will discuss what specific aspects of the blog project worked well, and why; explain areas of potential improvement; and share suggestions for adapting the project for other class situations. (Received September 20, 2010)

1067-H1-1791 **Matthew Leingang*** (leingang@courant.nyu.edu), Warren Weaver Hall, 251 Mercer St., New York, NY 10012. *Mashups for course websites with Yahoo! Pipes.*

RSS stands for Really Simple Syndication or Rich Site Summary, depending on who you ask. Many websites publish a rich set of RSS feeds, which can be processed by other websites as a form of syndicated content. But the regular structure of RSS as an XML application means that feeds can be easily edited ("munged") and combined ("mashed up"). Programming libraries exist for processing feeds, but Yahoo! Pipes makes this easy with a graphical user interface and no coding. We will discuss methods and applications of RSS feeds which might be suitable for a course website—for instance, combining feeds from SlideShare and scribd and publishing them to Facebook, or publishing your office hours on your blog automatically. (Received September 21, 2010)

1067-H1-2036 **Sherrie Serros*** (serrossj@uwec.edu), University of Wisconsin - Eau Claire, Hibbard Hall 502, Eau Claire, WI 54702, and **Erick B Hofacker** and **Rebecca Ledocq**. *Communicating Mathematically Through Podcasts.*

With funding by the University of Wisconsin System, we developed a project for 2010-2011, 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. All incoming freshmen in the system take a common placement exam to determine course placement at each institution.

To meet the goals of the grant, we are conducting multiple workshops with 20 high school math teachers in our area to discuss the transition for students from high school to collegiate mathematics. During these workshops, mathematical threshold concepts which impede student progress will be identified by the group. Once threshold concepts are identified, participants will create approximately 300 podcasts which may be used by students to overcome their misconceptions. Collegial critiques of the podcasts will address quality and appropriateness of each podcast before open access.

The complete collection will be available through the internet. High school students may then view podcasts to assist with areas of difficulty as identified through the early math placement test. Students will be allowed to provide feedback on the usefulness of each podcast once it is viewed. (Received September 22, 2010)

1067-H1-2039 **Erica L Johnson***, Dept of Mathematical and Computing Sciences, St. John Fisher College, 3690 East Ave, Rochester, NY 14618. *The Joy of Numbers and Wikis.* Preliminary report.

Course management systems like Blackboard support several electronic platforms that can be used to post class notes and facilitate a student-driven editing process as well as an electronic conversation. In particular, the Blog, Wiki, and Discussion Board features of Blackboard can all be harnessed to promote mathematical communication. In this presentation, we will discuss student use of the Wiki feature in Blackboard to create a set of class notes and produce solutions to selected homework exercises, thereby placing the onus of organizing and presenting the material on the students themselves. By involving the students in the revision process, they had to carefully read, reflect upon, and interact with the material. Furthermore, using this electronic medium allowed students to continue the conversation outside of the confines of class time and to work together to create a truly collaborative set of course notes and record of class events. This presentation will describe the creation and implementation of an inquiry-based number theory course for future high school mathematics teachers in which the class used Blackboard features to complement and supplement course dialogue. A discussion of the results will be included. (Received September 22, 2010)

1067-H1-2051 **Erick B Hofacker*** (erick.b.hofacker@uwrf.edu), University of Wisconsin - River Falls, 214C North Hall, River Falls, WI 54022, and **Kathryn T Ernie**, **Sherrie Serros**, **Kay Shager** and **Charles Serros**. *Life After Our 2010 MAA PREP – Emerging Technologies.*

During the summer of 2010 we conducted a MAA PREP – Integrating Emerging Technologies Into Undergraduate Mathematics Courses – in Bloomington, MN. During this week long workshop the 19 organizers and participants discussed different ways to incorporate different forms of technology into the classroom for the purposes of: communication, visualization, and assessment. The different forms of technology that were discussed included: podcasting, digital ink, clickers, online activities, online assessment, and various computer programs.

This presentation will include the three organizers and two participants sharing the effect the workshop has had on their teaching during the fall semester. New attempts at integrating different forms of technology will be discussed – podcasting, clicker use, online homework systems. There will also be a discussion about the online blog the group has used for communication, as well as an online shared Google document of useful math web resources for class. (Received September 22, 2010)

1067-H1-2130 **Andrew J Cousino***, Dept of Math, Cardwell Hall, Manhattan, KS 66502-2602, and **Andrew G Bennett**, Dept of Math, Cardwell Hall, Manhattan, KS 66502-2602. *Interactive Math for (Almost) All Devices.*

While some mobile browsers include the necessary software to render Flash and Java, there are many that do not. Therefore, there are definite advantages to authoring in only HTML and Javascript. With tools like MathJax and JSXGraph, it is possible to provide typeset mathematics and interactive elements for all devices (almost). We will demo a section of our upcoming online Pre-calculus textbook, using only the tools mentioned earlier, and talk about our experiences developing it. Our textbook is not just another PDF-like document, as there are interactive elements, dynamic examples, and a nonlinear layout of content. Finally, we would like to share our ideas on other ways such technologies can utilized in writing an online text, and how we see this medium developing. (Received September 22, 2010)

1067-H1-2186 **Jeremy M Riehl*** (jeremy.riehl@usma.edu), D/Math, Thayer Hall, West Point, NY 10996, **Lee A Evans** (lee.evans@usma.edu), D/Math, Thayer Hall, West Point, NY 10996, and **Kristin M Arney** (kristin.arney@usma.edu), D/Math, Thayer Hall, West Point, NY 10996. *On-Demand Mathematics: Creative Uses for Smartpen Technology.* Preliminary report.

The smartpen with a digital voice recorder is an emerging technology that has made its way into the classroom. The smartpen is marketed to students as an alternative to traditional note taking by synchronizing audio clips and notes into a single digital file. However, this technology provides interesting resources allowing educators to enhance students' learning experience both in and out of the classroom. In this session, we will discuss time-efficient ways to create supplemental video instruction. These videos augment traditional classroom instruction by allowing students to access on-demand videos that answer many common questions. Additionally, we will discuss ways to incorporate students in the creation of these videos. This is an active learning technique that affords students the opportunity to take responsibility for their own learning and sets the stage for a true collaborative learning environment. (Received September 22, 2010)

1067-H1-2206 **Klay Kruczek*** (kruczekk@wou.edu), Mathematics Department, 345 N. Monmouth Avenue, Monmouth, OR 97361. *Using Facebook in a Discrete Mathematics course.*

Facebook, the social networking website, has become a very popular way for students to communicate. In this talk, we will see how Facebook was used as a discussion board in a discrete mathematics course for pre-service K - 8 teachers. In particular, we will see what the instructor and students discussed on Facebook, its effectiveness as a communication device in the classroom, and privacy issues encountered along the way. We will look at the student population and content of the course. We will also consider the options for the use of Facebook in a course, which include creating a Facebook "group" and having students "friend" the instructor (who may have created a fake profile). Finally, we will discuss future uses based on student reactions. (Received September 22, 2010)

1067-H1-2237 **Frank Wattenberg*** (Frank.Wattenberg@usma.edu), Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996. *Using iPad class devices as entries into a situationally aware digital library to provide JIT/JIP (Just in Time/Just in Place) Mathematics.*

Devices like Apple's iPad and iPhone based on Apple's iOS4 and the Droids based on Google's Android OS know a great deal about their situation. Cell-phone assisted GPS tells them where they are and built-in accelerometers and compasses tell them how they are being held. Google Goggles combines these capabilities with analysis of photographs to provide even more situational information. This gives us the opportunity to provide situationally aware mathematics resources to students where they are. This session will discuss the possibility of SADL - a situationally-aware digital library and look at several examples of mathematics content for such a library. (Received September 22, 2010)

1067-H1-2269 **Carla C. van de Sande*** (carla.vandesande@asu.edu), School of Mathematical and Statistical Scienc, Arizona State University, PSA 633, P.O. Box 871804, Tempe, 85287, and **E. Hsu** (erichsu@math.sfsu.edu), San Francisco State University, Science Building 211, 1600 Holloway Ave., San Francisco, CA 94132. *The experience of newbie helpers in a mathematics, open, online, homework help forum: Becoming part of a community of helpers.*

Free, open, online, homework help forums are located on public websites and allow students anywhere in the world to post questions from their coursework and assignments and receive help asynchronously from anonymous volunteers. Such sites are especially popular for challenging, homework-intensive subject areas, like mathematics. The sites can adopt a participation structure that allows only select, vetted helpers who meet certain criteria to act as helpers (e.g., experts), or may allow any registered member to function in this role (called Spontaneous Online Help, or SOH sites). Some existing mathematics SOH sites exhibit a strong sense of community among the helpers, in the sense that the helpers correct one another, work collectively to help individual students, and engage in collegial banter. In such a context, helping others is transformed from a private, individual encounter into a public, communal activity. What does it look like for helpers to join such a community? We explored the enculturation process and experiences of five newbie (novice) helpers in a popular SOH forum that covers arithmetic through advanced mathematics. The participants spent eight consecutive weeks on the forum, participated in pre- and post interviews, and kept journals during their time as helpers. (Received September 22, 2010)

1067-H1-2382 **Aaron Wangberg*** (awangberg@winona.edu), 322 Gildemeister Hall, Winona State University, Winona, MN 55987. *Treatment for the "Submit Answer" Addict: Active Interventions for Struggling Calculus Students identified by WeBWorK Performance Data.*

Struggling students try every option, rewrite equivalent answers, and believe they "almost" remember the correct method. Online homework systems, such as WeBWorK, can gather an immense amount of student performance data and identify students practicing mind-numbing methods. In this talk, I'll share how we've used WeBWorK data to provide active interventions for Calculus students through interactive online tutorials and group activities. (Received September 23, 2010)

1067-H1-2407 **Robb Sinn*** (rsinn@northgeorgia.edu), Math/CS Dept., 82 College Circle, Dahlonega, GA 30597. *Real Messy Statistics and Survey Monkey.*

With weekly survey participation, we have built up a huge class data set. Along with demographic variables, we know the class distributions for psychological constructs like Narcissism, OCD, Perfectionism, Internet (Facebook) Addiction, and Toxic Relationship Beliefs. We also addressed class opinions on topics including the recent controversial Eminem-Rhianna music (and video) collaboration "Love the Way It Hurts," along with whether students at our school would vote in favor of a large fee increase to support starting a football team and building a stadium. Any online survey tool like Survey Monkey can be used. A sample size of 95 has worked out quite well. Chosen with care, the surveys lend variables and constructs for all the relevant statistical analyses needed in an introductory course, and the students reported - on a recent class survey - that they enjoy conducting class this way. One survey gathered requests for topics of future surveys. Warning: real data can be really messy. The session will provide hints on generating the needed data sets for reasonable example questions, dealing with the "mess," and the challenges that arise both with technology and regarding human subjects research. (Received September 23, 2010)

Humanistic Mathematics

1067-I1-22 **Esther M Pearson*** (epearson@lasell.edu), PO Box 1122, Groton, MA 01450. *"Making the Connection: Ethnic and Cultural Effects of Mathematics".*

This presentation examines chronological periods in history and how African Americans affected and were affected by mathematics. The African American experience from slavery through the Information Age is examined. Evidence within each period details how mathematics has profoundly affected the progress of African Americans. From their position as slaves to the representation of African Americans as 3/5th a human; to their liberation, right to read, right to vote, and right to fight in the armed services. From their migration from the south to the north, from inner city to suburbia, from blue collar labor to white collar, from business employee to business owner. This talk brings into perspective the need for African Americans to embrace mathematics as never before so that academic, social, and economic gains can be maintained and advanced in America. Why then, has mathematics not been held closely or embraced like a friend to those of African descent? (Received May 20, 2010)

1067-I1-86 **Emelie A Kenney*** (kenney@siena.edu), Department of Mathematics, Siena College, Loudonville, NY 12211. *Tales from the Underground: Polish Mathematics during World War II.*

Despite the oppressive and extremely dangerous conditions present in WWII Poland, scholars and students pursued, in a vast underground society, their intellectual interests. Perhaps in part because of the enormous effort expended in preceding decades to build what became known as the Polish School of Mathematics, even those scholars who had been brutalized in camps went on, after their release as the result of an international outcry, to teach and study in clandestine universities and schools. In this paper, we focus on the ordeals and triumphs of the mathematicians, mathematics teachers, and students of mathematics of Krakow, with special attention to the seven mathematicians who, along with 176 others, were arrested at the Jagiellonian University in the infamous Sonderaktion Krakau of November, 1939. (Received July 20, 2010)

1067-I1-90 **Todd CadwalladerOlsker*** (tcadwall@fullerton.edu), Mathematics Department, MH-154, 800 N. State College Blvd., Fullerton, CA 92831. *What do* we *mean by mathematical proof?*

Mathematical proof lies at the foundations of mathematics, but there are several notions of what mathematical proof is, or might be. There is a certain amount of tension between “formal” definitions of proof and how we, as a mathematical community, actually write, read, and use proofs. This presentation will review the body of literature that explores this tension, with an emphasis on how this tension manifests in the mathematics classroom. We will discuss how the various roles of mathematical proof affect how we define proof, the range of ideas about proof held by students, and pedagogy intended to help communities of students develop standards of proof that agree with those held by the larger community of mathematicians. (Received July 22, 2010)

1067-I1-242 **Chris Arney*** (david.arney@usma.edu), Dept of Math, USMA, West Point, NY 10928. *Cooperative Systems Course: The Mathematics of Harmony.*

The Cooperative Systems course connects various modeling methodologies and perspectives across mathematics and other disciplines to build a framework for humanistic/social problem solving involving cooperative entities. This presentation describes the elements of a new undergraduate mathematics course that involves innovative study to understand the utility and effectiveness of adaptive intelligent (cooperative) systems. This course looks at dynamic complex systems and networks that replace centralized organization or control with distributed cooperation (component collaboration) through the development of structures and processes for communicating, adapting, learning, reasoning, governing, organizing, and decision-making by people in the system. Most of the material is learned through studying, engaging, modeling and solving current, complex, capacious social problems and public issues. The major objectives of the course are to understand the mathematics and science of human thought, enjoyment, and problem solving through harmony in intelligent cooperation, learning, pattern analysis, decision-making, and cognition. (Received August 11, 2010)

1067-I1-368 **Jacqueline M Dewar*** (jdewar@lmu.edu), Loyola Marymount University, Math Dept - UH 2700, 1 LMU Drive, Los Angeles, CA 90045, **Lily Khadjavi** (lkhadjav@lmu.edu), Loyola Marymount University, Math Dept - UH 2700, 1 LMU drive, Los Angeles, CA 90045, and **Alissa Crans** (acrans@lmu.edu), Loyola Marymount University, 1 LMU Drive UH 2700, 1 LMU Drive, Los Angeles, CA 90045. *Mathematics and Equity, Past and Present, through the Lives and Work of Women Mathematicians.*

An interdisciplinary course, Women and Mathematics, examines the lives of women mathematicians throughout history, engages students in mathematical topics related to the work of these women, and addresses gender equity in K-to-doctoral-level mathematics schooling and careers. A TENSOR-MAA Women and Mathematics grant is supporting a team-teaching effort by the course originator to mentor two faculty in teaching this course. From the course we present a typical lesson: one that connects the life and work of Sonia Kovalevsky to an exploration of geometric series from historical, numerical, algebraic, visual and kinesthetic perspectives. The lesson also plumbs Kovalevsky‘s life and career for barriers to education, problems in finding work and work-family issues that continue to plague women in the 21st century. The course encourages students, some of whom are future K-12 teachers, to adopt a more expert view of mathematics as a study of patterns (rather than numbers), provides them with an opportunity to “do math” in a supportive environment, and prepares them to discuss the current US situation regarding women’s ability and participation in mathematics. The future teachers gain knowledge of equitable classroom practices and resolve to incorporate these into their teaching. (Received August 28, 2010)

1067-I1-371 **Reuben Hersh***, rhersh@gmail.com. *Jesse Douglas, Norman Levinson, and anti-semitism at MIT in the 1930's.*

A recent memoir by Fagi Levinson, Norman's widow, reveals a connection between the firing of Jesse Douglas and the hiring of Norman Levinson at MIT in 1937. (Received August 29, 2010)

1067-I1-431 **Kazem Mahdavi*** (kazem_Mahdavi@uttyler.edu), Dept. of Computer Science, RBN 3007, UT Tyler, Tyler, TX 75799. *A 2-week summer camp.*

We received a grant from Texas Higher Education Coordinating Board to conduct a two-week summer camp at the University of Texas at Tyler, for entering freshmen in STEM fields. In this paper we will discuss this two-week summer camp and its impact.

In the morning the participating students focused on learning mathematics, and in the afternoon the student participants got familiarized with the application of mathematics in sciences and engineering. There were seven faculty members involved with this grant, as well as eight teaching assistants. The participant students received a $2,000 scholarship that was provided through another university grant with a different PI.

We aimed at using Clarence F. Stephens' method of teaching. We involved students in learning and experimenting, while providing a humanistic atmosphere for them to learn and interact with different faculty members. We provided free dorm and food for the students. This helped the students to interact more with the teaching assistants and the faculty involved. This will help the to become part of mathematics, science, and engineering community. (Received September 08, 2010)

1067-I1-451 **Andrew G Borden*** (bordon1@att.net), 4707 Broadway, #150, San Antonio, TX 78209. *A Simulation of Evolutionary Psychology Using the Psychology of Personal Constructs.* Preliminary report.

According to the Psychology of Personal Constructs (George Kelly - 1955), human personality consists of dimensions, each of which can have a large positive or negative valence, or a value near zero, i.e. be irrelevant for a specified individual. Altruism/narcissism is an example of a personality dimension. Based on a specific personality structure, an individual adopts memes or patterns of behavior and/or belief (Susan Blackmore - 1999). Memes are to evolutionary psychology as genes are to evolutionary biology. A meme could be as simple as playing the recorder in an early music ensemble or as sophisticated as selecting mathematics research as a career. We identified candidate personality dimensions so that a personality can be described numerically. We then characterized the attractive power of selected memes in terms of the same dimensions and developed an attraction/avoidance function between personalities and memes. This allows us to predict whether an individual would choose to play the saxophone or write poetry...or would reject both choices. In the paper, we apply the attraction/avoidance function both to career choices and to avocatons. Most likely and least likely meme choices are reported. (Received September 04, 2010)

1067-I1-619 **Gregory L McColm*** (mccolm@usf.edu), Dept. of Mathematics & Statistics, 4202 E. Fowler Ave., PHY114, University of South Florida, Tampa, FL 33620. *Humanism, Realism, and Folk Mathematics: the Case of Reticular Geometry.*

Whether or not mathematical objects are discovered or created, they are arranged, exhibited, and explained by professional, multi-disciplinary, or amateur mathematicians. And mathematics created in a cumulative enterprise by middle class academics might be structurally different from mathematics created by a disparate and diverse assortment of scattered artisans and enthusiasts. Consider what we might call *Reticular Geometry*, i.e., the geometry of fitting geometric shapes (often polygonal or polyhedral) together into articulated structures. Archeologists can confirm the antiquity of this subject while historians can confirm its influence in fields from architecture to chemistry. But these confirmations are of its influence (via applications) as a *folk* subject, not as an explicitly recognized field of scholarship. And its presence in academic mathematics prior to the Renaissance can be seen only in scattered fragments, and its presence in academic mathematics is massive but diffuse. We argue that in this case, the mathematics we see is organized and used by human beings, and such organization and use reflects their interests, resources and social organization. (Received September 11, 2010)

1067-I1-977 **José María Menéndez***, Department of Mathematics and Statistics, PO Box 6942, Radford, VA 24142, and **Laura Jacobsen**. *Development of the appreciation of mathematics via teaching mathematics education for the public interest.* Preliminary report.

In this presentation we will share preliminary results from a study on how pre-service teachers (PST) for elementary and middle school react to a semester long course in mathematics for the social analysis. In particular, we will focus on identifying the most influential components of the course that change students dispositions and what perceptions of teaching and learning mathematics are affected and how. Preliminary results point at progress made in PSTs' (a) understanding of how to integrate mathematics and social issues, (b) appreciation for mathematics as a tool to understand "non mathematical" problems, and (c) a sense of agency to create mathematical learning opportunities that students will find interesting and relevant. A brief explication of the course syllabus and its placement in the context of the students' plan of studies will precede the research itself and the findings discussion. (Received September 17, 2010)

1067-I1-1279 **Deepak Basyal*** (deepakji@nmsu.edu), Dept of Mathematical Sciences, MSC 3MB P.O. Box 30001, Las Cruces, NM 88003-8001. *Treatment of and trouble with zero in three centuries of American arithmetic.*

The realization of zero as a number has a long history. Initially, zero (cipher) was used solely as a placeholder; however, zero got its rightful place when it was abstractly defined in the New Math of the 1960s. Zero's journey from 'placeholder to cardinality of the empty set' and 'from sunya to zero' makes a really good story. In this presentation I will discuss the fact that the authors of arithmetic books throughout American history avoided using arithmetic problems involving zero. Why and how zero was treated throughout the 18th and 19th centuries, and how and when transition points in the meaning of zero appeared with the passage of time, are the main concerns of this presentation. It was a troublemaker when it first appeared; however, it is a vital member of the number system of arithmetic in modern mathematics. (Received September 20, 2010)

1067-I1-1283 **Mike Pinter*** (mike.pinter@belmont.edu), Dept. of Mathematics and Computer Science, Nashville, TN 37212. *Exploring Mathematical Characters, in Fact and in Fiction.*

In my presentation, I will describe briefly a variety of mathematical "characters" that my students read about or whose ideas they explore during the Math Analytics course in the Belmont University Honors Program. My goals in this regard include that students gain a sense of considering mathematics as part of the human endeavor and that they also see cultural, psychological and emotional elements associated with people as they pursue mathematical ideas. The set of "characters" includes Paul Erdos and others as portrayed in The Man Who Loved Only Numbers, Jeffrey Wiles as seen in The Proof video, Robert Moses and his work with The Algebra Project, Alan Turing and Kurt Godel (including their portrayal in A Madman Dreams of Turing Machines), Danica McKellar as she combines her math and acting passions, the fictional Christopher Boone in The Curious Incident of the Dog in the Night-Time, and the fictional Max Cohen in the film Pi. (Received September 20, 2010)

1067-I1-1406 **Marc Chamberland*** (chamberl@math.grinnell.edu), 1116 8th Ave., Department of Mathematics and Statistics, Grinnell, IA 50112. *Habits of Creative Mathematicians.* Preliminary report.

While mathematicians consider their work as creative as any other discipline, articulating what comprises their creative process is rarely examined. In this talk, we look at aspects of creativity which have served mathematicians of many generations. This includes the changing face of collaboration, depth versus breadth, the various roles of the computer (number cruncher, pattern finder, etc), the value of independent investigation, the benefits of rest (both physical and mental), and the psychological underpinnings of our desire to be creative. Examples will be drawn from both pure and applied mathematics. (Received September 20, 2010)

1067-I1-1506 **Carl Behrens***, 5107 Cedar Rd., Alexandria, VA 22309. *Psychologism as an Issue in the Mathematical Philosophy of Bertrand Russell.*

Psychologism is the name 19th Century philosophers gave to the doctrine that reduced logical entities, such as propositions, universals, or numbers, to mental states or mental activities. There was a great deal of concern about psychologism in the late 19th Century, particularly after the Darwinian revolution. Both Bertrand Russell and G.E. Moore in England, and Gottlob Frege on the continent, formulated their analytical philosophy largely in opposition to psychologism and naturalism. Since contemporary mathematics is largely founded on Russell's philosophical approach, it is interesting to review the issue of psychologism in light of current views of the relation of mental states and logical processes. (Received September 21, 2010)

1067-I1-1678 **Toke L Knudsen*** (toke.knudsen@oneonta.edu), Dept. of Math, Comp. Sci., and Stats, SUNY Oneonta, 108 Ravine Parkway, Oneonta, NY 13820. *Poetry in Sanskrit Mathematics.*

While many Sanskrit treatises are written in metrical form, they do not necessarily qualify as poetry. This is also true for mathematical treatises in Sanskrit. However, a number of Indian mathematicians, including Bhāskara II (b. 1114 CE) and Jñānarāja (fl. 1500 CE), employ poetry in their presentation of problems given to the reader of their works. These problems employ not only poetic imagery, but also advanced poetic techniques, such as double entendre. As such, a unique experience for the reader and the student alike, is created.

In addition to providing a history, the talk will focus on the scholarly and pedagogical considerations behind the use of such poetry in Sanskrit mathematics, as well as the implications for the learner. (Received September 21, 2010)

1067-I1-1699 **Angie Hodge*** (Angela.Hodge@ndsu.edu) and **Christina D Weber** (Christna.D.Weber@ndsu.edu). *Success in the university mathematics classroom: Learning from the voices of students.*

How do we begin to develop a more humanistic approach to teaching university mathematics? In this presentation, we will address this question through an analysis of research data we have collected (both quantitative surveys and qualitative interviews) over the past two years. In this research, we focus on what has helped students succeed in the mathematics classroom. We are particularly interested in understanding what has helped women and other minority groups thrive in mathematics classrooms that serve science, technology, engineering, and mathematics (STEM). In particular, we are interested in how instructors can develop equity and equality in mathematics programs and fields where mathematics acts as a gatekeeper. Given the lack of women and minorities in the STEM fields, our research concerns focus on how to help keep these groups in the mathematics classroom, which are essential to success in these fields. We will include in our presentation the interrelationship between students' demographic backgrounds and classroom dynamics to see how we can better serve women, minorities, and those from rural and first generation university backgrounds. (Received September 21, 2010)

1067-I1-1848 **Erin R. Moss*** (erin.moss@millersville.edu), Department of Mathematics, Millersville University, P.O. Box 1002, Millersville, PA 17551-0302. *Transmitting Philosophies of Mathematics Through Pedagogy.*

The majority of Americans believe that mathematics is the domain of an elite few–the ultra-logical and intellectually brilliant – with no room for their own contributions. A significant mechanism by which this negative perception is perpetuated is in the mathematics classroom via pedagogy. Teachers from Kindergarten through the college level most commonly engage in a transmission-based pedagogy, with the instructor positioned as the sole mathematical authority in the classroom. To encourage higher rates of achievement and persistence in the American population and to build a more equitable society, we must believe it possible for all people to take ownership of mathematics and contribute to its development and use. In a classroom setting, this means allowing students to assume mathematical authority by co-creating mathematics with one another and with their teacher. In this talk, I share my experiences teaching mathematics courses for future elementary teachers and the ways that my philosophy of mathematics guides my approach to the course. In particular, I discuss pedagogical strategies I use to achieve my aims of increasing students' responsibility for creating and communicating mathematics. (Received September 22, 2010)

1067-I1-1896 **James P Fulton*** (fultonj@sunysuffolk.edu), Suffolk County Community College, 533 College Rd, Selden, NY 11784. *A Humanistic Approach to Teaching Mathematics to the Liberal Arts Student.*

Mathematics for the Liberal Arts can be one of the most difficult classes to teach. The goals and purposes of the course are very obscure. Traditionally there are two approaches: The first randomly splices together topics such as logic, set theory, number systems, etc., with no real connection between topics. The other highlights the utility of mathematics in modeling the world around us, however, modeling requires a level of sophistication beyond many taking this course. Since this is their last exposure to mathematics we'd like it to be meaningful.

Our humanistic approach is to treat it as one of the liberal arts-a mathematics appreciation course with an underlying theme, and purpose, giving mathematicians the opportunity to showcase the real beauty and importance of mathematics. We focus on the origins of mathematics and the fundamental questions related to its development through philosophy, history, epistemology, cognition, and psychology, thereby connecting it to their other freshmen courses. Our motivation is that an educated person needs to understand the place and relevance of mathematics. They should read and understand NY Times bestsellers on mathematics. This talk presents our approach, student remarks, and the accompanying textbook developed for the course. (Received September 22, 2010)

1067-I1-1988 **Teodora B. Cox*** (teodora.cox@fredonia.edu), SUNY Fredonia, Department of Mathematical Sciences, Fenton Hall 207, Fredonia, NY 14063. *Teaching Reading and Writing Mathematics for Social Justice.*

Issues of social justice and power are slowly making their way in the K-12 curriculum. This presentation will address some of the following questions: What are pre-service K-12 mathematics teachers' perceptions of social justice? What is teaching for social justice? How do you teach someone to teach for social justice without compromising the rigorous study of mathematics? The presenter will share insights gained from teaching a mathematics education course to K-12 teachers in which the students used literature and real-life data to develop lessons and units on their chosen mathematics content and issues of social justice. The emphasis of the assignments was on the promotion of problem solving and the effective and persuasive communication of mathematical ideas. Lastly, the presenter will share ideas for making mathematics more relevant and meaningful to students and teachers via the use of real-life data. (Received September 22, 2010)

1067-I1-2093 **Clyde l. Greeno*** (greeno@malei.org), The MALEI Institute, P.O. Box 54845, Tulsa, OK 74155. *Mathematical Learning: A Humanistic Re-formation of Core-curricular Instruction.* Preliminary report.

Clinical research identifies humanly natural, rational processes of acquiring personal mathematical knowledge . . . which also develop personal powers for creative, analytic, managerial thinking/learning. Apart from differences in mathematical sophistication, those natural are some of the same ones used by professional research mathematicians. They are professional learners, and their mathematical arts mostly are only refinements of what on the streets is called "using common sense". Implications for curricular education in mathematics are profound. All humans are natural theorists. Their ability to learn by theorizing . . . albeit loosely and often subconsciously . . . is their primary tool for their survival by striving to manage whatever affects their lives. But the prevailing American modes of core-curricular instruction in mathematics commonly have quite the opposite effect on students. Because the curriculum is not designed to be commonsensible to them, they cannot learn the material, mathematically (i.e. not theoristically). Instead, they must resort to irrational "template training" in order to emulate whatever texts and teachers do. This presentation summarizes the proceedings and findings of a project on the theoristic learning of core-curricular mathematics. (Received September 22, 2010)

1067-I1-2215 **Philip K Hotchkiss*** (photchkiss@wsc.ma.edu), Department of Mathematics, Westfield State University, Westfield, MA 01086, and **Julian F Fleron**, **Volker Ecke** and **Christine von Renessee**. *Student Inquiry into the Limits of Knowledge - Removing Barriers in Mathematics for Liberal Arts.* Preliminary report.

Liberal arts students often face a huge barrier in mathematics because they think it does not touch their world in significant ways. In this talk we share inquiry-based materials and approaches we have developed to help move beyond these barriers by focusing on the themes "What do we know?" and "Are there limits to knowledge?"

Spurred by Catherine's admonishment "It doesn't prove anything!" to Hal in David Auburn's Proof, students consider questions of existence, and the limits of knowledge, by interacting with: debates about perception (including Plato's Allegory of the Cave and Descartes cogito); types of reasoning and burdens of proof; mathematical logic and proof, including non-existence proofs; relativity, uncertainty, and incompleteness – their scientific and cultural roles; chaos and sensitive dependence on initial conditions (via Ray Bradbury's "Sound of Thunder" whose 1952 butterfly predates the "founding work" by Lorenz); etc.

We will discuss how one can integrate these deep mathematical topics into inquiry based approaches, why these topics are important for mathematics for liberal arts students, and how we hope students will benefit from these experiences. (Received September 22, 2010)

1067-I1-2318 **Susan L. Addington*** (saddingt@csusb.edu), Math Dept., CSUSB, 5500 University Pkwy., San Bernardino, CA 92407, and **David Dennis** (david.dennis@earthlink.net), 4249 Cedar Dr., San Bernardino, CA 92407. *Physical Math for Elementary Teachers: Reconnecting Mathematics with the Body Using Mirror Neurons.*

Neuroscience is discovering that conscious, rational thought is executed by "recycling" neurons whose function was evolved for physical action and sensory input. We know that small children learn with their bodies. However, the curriculum for elementary school has narrowed to a focus on written symbols, having eliminated physical calculating devices and most measurement. A new book for future elementary teachers, Measuring the World, emphasizes the physical basis for elementary mathematics. To help teachers reconnect with the understanding built into their bodies and brains, physical activities are central: walking and turning, measuring things, making objects. We discuss activities for teaching angles, a topic that is poorly understood by many students. Many teachers of teachers are not aware that this is a difficult concept. One of the activities has students make their own protractors by folding paper. The demonstration is on video so that everyone can see and imitate what to do. This is facilitated by the recently discovered mirror neurons, which allow the viewer to imitate an observed action. ("Monkey see, monkey do.") Video is not only stunningly effective, but it also makes it much easier for traditional-style teachers to include activities in their classes. (Received September 22, 2010)

1067-I1-2348 **Andrew J. Miller*** (andrew.miller@belmont.edu), Dept of Mathematics and Computer Science, Belmont University, 1900 Belmont Blvd, Nashville, TN 37212. *"Beauty is Truth, Truth Beauty": The Aesthetics of Mathematical Arguments.* Preliminary report.

The beauty of the subject is one of many things that draw mathematicians to the field. Such beauty is not limited to the objects of study. Rather, a greater part of the delight mathematicians take in their subject is found in the aesthetics of proofs, the rigorous arguments at the core of the field. Such beauty is often difficult to describe to the non-mathematician. We explore some of the many natural questions prompted by this reality, including: What makes a proof beautiful? How does this contrast and compare to beauty in other fields? Can a non-mathematical argument be beautiful? The discussion will include examples of beautiful proofs. (Received September 22, 2010)

1067-I1-2397 **Satish C. Bhatnagar*** (bhatnaga@unlv.nevada.edu), 308 Cavalla Street, Henderson, NV 89074. *Three Humanistic Approaches.* Preliminary report.

This paper mainly deals with three approaches that the author has successfully integrated in the teaching all lower division (100-200 levels) math courses. Spread over a semester, they are three writing exercises: Analysis of Test #1, Watching one Mathematical video like - The Proof, A Beautiful Mind, or Mathematical Mystery Tour, and finally Relating the course material with any other course, hobby, or project. Each critical report (no summary) has to be in 250 words. They are not mandatory, yet nearly 90 % of the students do them for extra credits.

However, the subliminal theme and an undercurrent of all lower division math courses are emphasized by phrases and clichés like Mathematical Thinking (grounded in deductive reasoning), Nurture Mathematics, Think Mathematically etc. Patience, practice and problem solving are the pillars of not only of a math course but also of life, at large. For instance, choosing the coordinates in a word problem is connected with the scenario of right choices in life. There are moments in every lecture that a seasoned or sensitive instructor can capitalize and relate math with life values. The paper has more examples. It is the ultimate grounding or humanizing of basic mathematics. (Received September 23, 2010)

1067-I1-2419 **Russell W Howell*** (howell@westmont.edu), Department of Mathematics, Westmont College, 955 La Paz Road, Santa Barbara, CA 93108. *Grading Without Numbers.*

Students often expect grading scales on a mathematics test to conform to the standard 90/80/70/60 cut-offs. It is not uncommon in certain courses, however, for something like 50/100 to equate with a B. When papers with such marks on them are returned to the students there are a variety of reactions. Many simply file the paper away in embarrassment and never look at extensive comments that their instructor put on the exam. This presentation describes an experiment where papers are returned with only written comments: no numerical markings or grade indications at all. Students are then asked to evaluate the comments and their performance in later consultations with the instructor.

This paper describes the details of this approach, the reactions from students, and plans for future efforts to grade without numbers. (Received September 23, 2010)

Influences of the Calculus Reform Movement on the Teaching of Mathematics

1067-J1-73 **Bill Marion*** (Bill.Marion@valpo.edu), Department of Math and Computer Science, Valparaiso University, Valparaiso, IN 46383. *Calculus Reform and Discrete Mathematics.*

The Calculus Reform Movement paved the way for undergraduate mathematics faculty to move away from relying exclusively on the lecture method to teach Calculus. At Valparaiso University the 4-credit Calculus I and II courses are taught in a 3+2 mode with weekly 90-minute computer labs, using Maple as the computer algebra system of choice. The 3-credit discrete mathematics course we offer is required of all computer science and computer engineering majors. A CS I-type course is a prerequisite and Calculus I is a co-requisite.

Two years ago I began to incorporate some Maple examples in my discrete mathematics course to help students better understand some of the more abstract concepts introduced in the course, such as inductive and deductive reasoning and the formal definitions of big-Oh, big-Omega and big-Theta. In addition, since all of the students have had at least one programming course, I have been assigning team projects which make use of the programming facility in Maple. Examples of both programming and non-programming exercises will be illustrated. I will also describe some of the students' reactions to these types of assignments, some my own observations and some changes I intend to make when I teach the course in the Spring of 2011. (Received July 12, 2010)

1067-J1-246 **Mariah Birgen*** (mariah.birgen@wartburg.edu), 100 Wartburg Blvd., Waverly, IA 50677, and **Brian Birgen** (brian.birgen@wartburg.edu), 100 Wartburg Blvd., Waverly, IA 50677. *21st Century Calculus Reform: Don't Just Paint the Walls and Rearrange the Furniture.*

Even with earlier Reform efforts, Calculus content has stayed constant since the space race. It is the first (and often only) course for our best and brightest students. The curriculum is designed to satisfy the requirements of our Engineering majors. It is dreadfully inappropriate for almost all other students in the class, but what can be done? Applied Calculus followed by Foundational Calculus is our answer. First, engage all students in Calculus concepts using modeling to teach through complex, relevant problems. Once students are warmed up to college-level math and engaged in modeling, they take a semester of Calculus techniques. Or, they continue in a different course of study having a deeper understanding of the value and links between Calculus and tough ideas from within their discipline. In this presentation, we will address our history with Calculus Reform at Michigan and our work with students at a small, liberal-arts college. We will then explain the genesis and implementation of our Transformation. Time will be spent explaining the nuts and bolts, including software, classroom techniques, and textbooks and audience members will be given syllabi and links to relevant material. We will follow up with some preliminary assessment results as well as future plans. (Received August 12, 2010)

1067-J1-544 **Robert P Webber*** (webberrp@longwood.edu), Math and Computer Science Department, 201 High Street, Longwood University, Farmville, VA 23909. *Finding the Sum of an Infinite Series.*

Calculus reform, with its emphasis on numerical results, has altered how we teach infinite series. Historically, most classroom work on series focused on convergence tests. Actually finding the sum was computationally infeasible and thus was largely ignored, except for geometric and alternating series. Today's technology allows us to find the sum of many other convergent series to within any desired accuracy, usually by adding up the first finite number of terms and getting a bound on the sum of the remaining terms. Now when those pesky engineering students in the back of the room ask, "OK, so the series converges. What is the sum?", we can show them how to find the answer.

This presentation will discuss some of the approximation results and where (and if) they are included in popular calculus texts. (Received September 08, 2010)

1067-J1-557 **William Johnston*** (billjohnston@rmc.edu), Randolph-Macon College, P.O. Box 5005, Ashland, VA 23005-5505, and **Alex M McAllister** (alex.mcallister@centre.edu), Centre College, 600 W. Walnut St., Danville, KY 40422. *A Survey Transition Course.*

The Calculus Reform Movement was in part initiated to encourage more calculus students to enroll in upper-level courses, resulting in a higher number of mathematics majors. (The Movement's inaugural 1987 colloquium title included the phrase *A Pump, Not a Filter.*) While this desired increase did not occur on the national level over the following 20 years, the establishment of the goal did influence many mathematics departments to consider other curricular strategies to increase enrollment and boost majors. One institution, Centre College, established a sophomore-level Transition course with two new features: as a *Survey* of many different mathematical subfields; and with one of these subfields, *Mathematical Logic*, both as interesting in its own right and to explain method of proofs. This presentation describes particular features of the institution's *Survey Transition Course* that coincided with a significant growth in the number of majors there. (Received September 09, 2010)

1067-J1-1053 **Duff Campbell*** (campbell@hendrix.eu), Dept. of Mathematics and Computer Science, 1600 Washington Ave., Conway, AR 72212. *Differential Equations as a basis for Calculus II.*

We have developed an approach to Calculus II which uses initial value problems (IVP's) to motivate most of the course. We start with population models $\frac{dP}{dt} = kP$ and $\frac{dP}{dt} = kP\left(1 - \frac{P}{N}\right)$. Graphical analysis is used to study the geometry of solutions. The need for analytic solutions leads to separation of variables and partial fractions. The standard exponential as introduced as the unique solution to the IVP $\frac{dy}{dt} = y$, $y(0) = 1$, and the natural logarithm is introduced as the unique solution to the IVP $\frac{dy}{dt} = \frac{1}{t}$, $y(1) = 0$. The Existence and Uniqueness Theorem for Diff. Eq. is used to show that the former behaves like an exponential and the latter behaves like a logarithm, as well as showing that these two functions are inverses of one another. Trigonometric functions are defined as pairs of functions which satisfy coupled IVP's. Tweaking these coupled IVP's leads to hyperbolic trigonometric functions, inverse trigonometric functions, and more. After the other standard analytic techniques (integration by parts, partial fractions, etc.) have been introduced, Picard iteration provides a segue from differential equations to sequences and power series. A variety of modeling problems are used throughout the course. (Received September 17, 2010)

1067-J1-1139 **Patricia Baggett*** (baggett@nmsu.edu), Dept of Mathematical Sciences, MSC 3MB P.O. Box 30001, New Mexico State University, Las Cruces, NM 88003-8001, and **Andrzej Ehrenfeucht** (andrzej.ehrenfeucht@colorado.edu), Computer Science Department, P.O. Box 430, University of Colorado, Boulder, CO 80309-0430. *Calculus reform: What next?*

The calculus reform movement left three aspects of calculus courses unchanged. (1) In applications students are still given mathematical models of situations. and their work ends when they design appropriate formulas. (2) The main concept is the derivative, and the (Riemann) integral is mainly handled by antiderivatives. (This approach ignores the 20th century work of Lebesgue and Kolmogorov.) (3) The intuitive introduction of derivative and integral is geometric and based on the graph of a function (the derivative is the slope of the tangent line and the integral is the area below the graph). We will describe an experimental calculus course taught three times at New Mexico State University in which: (1) Students derived mathematical models of physical objects, and after deriving appropriate formulas, performed all necessary computations and constructed the objects. (2) The concept of the integral was based on Lebesgue's and not Riemann's definition. (3) The concepts of derivative and integral were introduced (more abstractly) without reference to the graph of a function. We will discuss good and bad aspects of this approach, and its possible use in mainline calculus courses. (Received September 19, 2010)

1067-J1-1150 **Jack Bookman*** (bookman@math.duke.edu), Mathematics Department Box 90320, Duke University, Durham, NC 27708-0320. *Twenty Years of Calculus Reform at Duke University.* Preliminary report.

From 1989 -1994, Duke University was the recipient of one of the first large NSF funded projects to reform calculus, "Project CALC." In this presentation. I will discuss the efforts to maintain the changes made, as well as efforts to adapt the program to reflect changing faculty, technology and financial conditions. In particular, I will first, briefly, address the profound changes made to content and pedagogy by Project CALC and then discuss how those innovations in content and pedagogy have evolved over the last twenty years to reflect those changing conditions. Since graduate students do a significant amount of the teaching of calculus at Duke University, I will also address how the teacher training for graduate students has been an important factor in both influencing and impeding change. I will also discuss how changes in the Advance Placement Calculus program have influenced both the content and the level of courses we teach, the possible sources of resistance to change, and the challenges facing Duke's calculus program in the near future. (Received September 19, 2010)

1067-J1-1333 **Michael A Brilleslyper*** (mike.brilleslyper@usafa.edu), 2354 Fairchild Drive Suite 6D124, USAF Academy, CO 80840-6252, **Trae D Holcomb** (trae.holcomb@usafa.edu), 2354 Fairchild Drive Suite 6D124, USAF Academy, CO 80840-6252, and **Dustin D Keck** (dustin.keck@usafa.edu), 2354 Farichild Drive Suite 6D124, USAF Academy, CO 80840-6252. *Not Just Grading the Answer: Assessing Process and Communication Effectively and Efficiently with Rubrics.*

Calculus reform ushered in a host of new and different types of questions and assignments. With a de-emphasis on mechanical computation and more time spent on conceptual problems, interpretation, modeling, and graphing, different and efficient feedback instruments are needed more than ever. The grading burden on instructors can be enormous, and it is increasingly more difficult to assess students across the variety of assignments and problems they typically now encounter. In an effort to address this issue, we have developed and widely implemented a system using generic and highly flexible rubrics. More than just a grading tool, the rubrics are integrated into the daily expectations for student work. Through constant use and reinforcement, students come to accept that all their work will be judged against the three rubric criteria of being *well-organized, well-communicated*, and *demonstrating essentially correct mathematics.* The criteria encapsulate the essence of the reform movement by evaluating student work broadly and holistically against a set of criteria that forms the foundation for effective problem-solving. This talk will highlight how incorporating the rubrics benefits student learning and also briefly discuss student reaction to their use. (Received September 21, 2010)

1067-J1-1368 **Michael E Boardman*** (boardman@pacificu.edu), Mathematics and Computer Science, Pacific University, 2043 College Way, Forest Grove, OR 97116, and **Stephen L Davis** (stdavis@davidson.edu), Davidson College, Box 6391, Davidson, NC 28035. *Calculus Reform and AP Calculus.*

A major revision of AP Calculus occurred in the early 1990's concurrent with the calculus reform movement, and much of the spirit of that reform is evident in the revision. We will present highlights of how AP Calculus has appropriated elements of reform calculus, and discuss the extent to which these elements are reflected in a timed high-stakes exam, the AP Calculus exam. The presenters are the Chair of the AP-Calculus Development Committee and the Chief Reader for the exam. (Received September 20, 2010)

1067-J1-1788 **Ann E Moskol*** (amoskol@ric.edu), Math/CS Department, Rhode Island College, Providence, RI 02908. *Teaching College Mathematics Before, During and after the Calculus Reform Movement: A Retrospective Prospective.* Preliminary report.

This talk will address how the calculus reform movement has changed the topics, pedagogy and evaluation of PreCalculus and Calculus courses that I have taught over my 35 year career. Whenever possible, I will compare actual notes, texts, outlines and/or evaluation materials that I have used. Besides addressing the changes in courses, I will also address the changes in the student body that have also affected how I teach and evaluate. (Received September 21, 2010)

1067-J1-1993 **Marcus Pendergrass*** (mpendergrass@hsc.edu), PO Box 174, Hampden-Sydney College, 1 College Road, Hampden-Sydney, VA 23943. *Bayesian Analysis of a Real Galton Board.* Preliminary report.

While it is common practice to use an ideal (or simulated) Galton board to illustrate the binomial distribution with $p = 1/2$, it is less common to subject data from a *real* Galton board to a statistical analysis to see whether the data actually come from a binomial distribution. We will present such an analysis, which was assigned as a project for a calculus-based statistics course. A Bayesian approach proves to be natural here, with a prior distribution that is binomial. Graphical, numerical, and algebraic perspectives all contribute to an understanding of this analysis. (Received September 22, 2010)

1067-J1-1995 **Teodora B. Cox*** (teodora.cox@fredonia.edu), SUNY Fredonia, Department of Mathematical Sciences, Fenton Hall 207, Fredonia, NY 14063, and **Stacey Singer** (ssinger@salamancany.org). *The Impact of Web-Based Homework on University Calculus Students.*

This presentation addresses characteristics and benefits of the use of technology for assessment and feedback in University Calculus classes in a liberal arts university mathematics department. In this mixed-methods study, the authors examined the effectiveness of web-based vs. paper-based homework on calculus students' final grades. Furthermore, we examined the perceptions of the students of the use of the two kinds of homework assessments. The presentation will conclude with implications for the use of web-based homework for students and instructors. (Received September 22, 2010)

1067-J1-2060 **Erick B Hofacker*** (erick.b.hofacker@uwrf.edu), University of Wisconsin - River Falls, 214C North Hall, River Falls, WI 54022. *An Emphasis on Application and Communication through Podcasts.*

This multiple semester project in Business Calculus is taught in a manner that focuses on conceptual understanding and the solving of real-life applications. There is also an end of the semester project integrated into the course which is evaluated by additional faculty from both the math department and the business department.

Technology is heavily integrated into the course, as it meets in a computer lab. At the beginning of the semester, students are introduced to instructor produced podcasts, which connects to the material they are currently learning. This is either a short lesson on a concept or the solving of a specific problem. Student groups or individuals begin making their own podcasts of solutions to problems they would complete as part of their homework assignments. Each student is typically responsible for making one podcast every two weeks, and more than one group would create a podcast for each problem. In essence, the students created a detailed solution's manual for the homework, which was evaluated and corrected by the instructor. The emphasis is on not only correct solutions, but correct reasoning and explanation. Students are provided an opportunity to engage in mathematical communication. (Received September 22, 2010)

1067-J1-2070 **Patti Frazer Lock*** (plock@stlawu.edu), Dept of Math, CS, and Stats, St. Lawrence University, Canton, NY 13617. *Have a Good Conclusion: The Value of Ending a Year-Long Calculus Course with an Introduction to Differential Equations.* Preliminary report.

The ideas arising from the calculus reform movement have changed just about everything in how and what the speaker teaches in her Calculus I and II courses. One of the most unanticipated and profound changes has come from the inclusion at the end of Calculus II of an introduction to differential equations. This one-month segment serves as a way to reinforce the material learned in both Calculus I and Calculus II while tying the whole year together. It also provides a way to show students the power of mathematics in a very wide variety of applications. And it is fun! The speaker will discuss some interesting examples done in class and the impact of this change on enrollments and majors and student attitudes toward math. (Received September 22, 2010)

1067-J1-2078 **Stephen R. Hilbert*** (hilbert@ithaca.edu), 208 Northview West, Ithaca, NY 14850. *Comparing Calculus classes before the start of Calculus Reform and Calculus classes today.*

I will compare calculus 1and 2 classes I taught in the early 1980's (before 1986) to the calculus 1 and 2 classes I taught recently up to and including the academic year 2009-2010. Among the topics I will compare are 1) exams and final exams 2) what was the basis for students grades and how were the grades calculated 3) what a typical lesson was like 4) what was the curriculum 5) what technology was used 6) what textbooks were used 7) what was expected outside of the classroom, 8) when I taught the course what was I satisfied with 9) what was I dissatisfied with. Reflecting on my experience teaching calculus for over 40 years: I will try to give personal answers to the questions: 1) what has been gained? 2) what has been lost?, 3) what is the same ? and 4) what is different?. (Received September 22, 2010)

1067-J1-2083 **Beth Schaubroeck*** (beth.schaubroeck@usafa.edu), HQ USAFA/DFMS, 2354 Fairchild Dr, Ste 6D188, USAF Academy, CO 80840-6252, and **Michael Courtney**. *Preparation for a technical core: Algebra & trigonometry at the Air Force Academy.* Preliminary report.

At the Air Force Academy, we face the challenge of preparing students to take an extensive technical core of classes. The "traditional" algebra & trigonometry course was not meeting the need of adequately preparing students for this technical core, so major changes were made to course content and structure. We report on a reformed version of algebra & trigonometry with an emphasis on modeling, and give preliminary indications of whether our reform efforts were successful. (Received September 22, 2010)

1067-J1-2092 **Kristin Arney*** (kristin.arney@usma.edu), 646 Swift Drive, D/Math, West Point, NY 10996, **Hilary Fletcher** (hilary.deremigio@usma.edu), 646 Swift Drive, D/Math, West Point, NY 10996, and **Gerald Kobylski** (gerald.kobylski@usma.edu), 6464 Swift Drive, D/Math, West Point, NY 10996. *Using Mathematical Modeling in Undergraduate Mathematics Courses to Promote Creativity and Critical Thinking.*

Literature in college education supports the vital need to develop creative and critical thinkers who can solve complex and unfamiliar problems while also revealing how these skills are lacking in many college graduates. In this discussion we will describe a Mathematical Modeling Process that we have used during the past few years with a goal of promoting creativity and critical thinking. Mathematical modeling is more than just creating a function to represent some real-world phenomenon and then solving for a mathematical answer; instead we promote an iterative mathematical modeling process that contains three steps: transform, solve, and interpret. We will define each step, the corresponding subcomponents, and will describe how we use this process throughout a four course mathematics sequence. We will also highlight how we have promoted this process with other disciplines at West Point. Finally, we will give specific examples of how mathematical modeling can be integrated into courses that typically focus on "standard" mathematical topics (i.e., finding the inverse of a matrix, row reduction, understanding functions, etc.). (Received September 22, 2010)

1067-J1-2289 **Steven W. Morics*** (steven_morics@redlands.edu), University of Redlands, 1200 E. Colton Ave., Redlands, CA 92373. *Getting in on the Ground Floor: How Growing Up with Calculus Reform Helps with Web 2.0.*

Despite missing (by a year) my undergraduate institution's foray into calculus reform, I have spent my entire career under the influence of the reform movement. Exposure to innovative techniques, through participation in Project NExT and through working with reform-minded colleagues, has kept me engaged in the process of looking for new and different ways to convey mathematical concepts and skills to my students. This approach to preparing my classes has helped me to navigate the new reality of Web 2.0.

The growth of the internet has increased the availability of browser-based free or cheap software, which allows students the ability to access vast amounts of information on their own and through collaboration with others. These new products provide access to powerful mathematical tools and rich archives of information. The practice of continuing to look for new ways to develop students' abilities and assess their progress developed as part of the reform movement has served to help guide a path through the new opportunities the Web 2.0 technologies provide. Through student surveys and anecdotal evidence, this talk will discuss how coming of age in the reform movement can inform pedagogical choices concerning these new technologies. (Received September 22, 2010)

1067-J1-2315 **Sarah L Mabrouk*** (smabrouk@framingham.edu), Framingham State University, 100 State Street, PO Box 9101, Framingham, MA 01701-9101. *Reflections on Calculus Reform: How I Was Taught vs. How I Teach.*

Calculus reform changed the emphasis of the calculus sequence from producing students who are better symbolic manipulators to producing those who understand as well as can interpret, explain, visualize, and apply the concepts and methods that they study and learn. As one who was taught using the traditional approach as well as whose initial teaching experiences (teaching fellow and then lecturer) were from the traditional point of view, teaching a conceptual calculus course incorporating the use of writing and graphing calculators had a profound and lasting effect. In this presentation, I will contrast how I learned various topics in the calculus sequence with how I teach these topics in my classes using physical demonstrations and explorations, technology such as Maple and Winplot, and assignments and projects that include writing, open-ended problems, and real-life applications. (Received September 22, 2010)

1067-J1-2379 **Paul E Seeburger*** (pseeburger@monroecc.edu), 1000 E. Henrietta Rd., Rochester, NY 14623. *Making Calculus Come Alive with Dynamic Visualization.* Preliminary report.

A tour of several Java applets developed by the presenter to help students visualize calculus. Although the presenter has developed over 100 applets for various calculus textbooks, all of the applets demonstrated in this presentation can be found on the presenter's webpage. Illustrated concepts include piece-wise functions, tangent lines, sketching derivative graphs from the graph of a function, Riemann sums, accumulation/area functions and the Fundamental Theorem of Calculus, slope fields, washer and shell methods, volumes with a common cross-section, 3D graphs of functions of two variables, parametric curves and surfaces, etc. In addition to his work on applets for visualizing single variable calculus, the presenter is also the PI of an NSF funded project that focuses on helping students visualize multivariable calculus. See http://web.monroecc.edu/calcNSF. (Received September 22, 2010)

Innovations in Service-Learning at All Levels

1067-K1-76 **Shafii-Mousavi Morteza*** (mshafii@iusb.edu), Mathematical Sciences, PO Box 7111, South Bend, IN 46634-7111, and **Kochanowski Paul** (pkochano@iusb.edu), Business &Economics, PO Box 7111, South Bend, IN 46634. *Service-Learning in an Interdisciplinary Mathematics and Economics Course.*

In this article, we discuss the use of client-driven projects – projects that are posed by business, government, and non-profit organizations and based upon real problems facing the organization – in the mathematics classroom. Although client-driven projects have long been used in business and engineering education, their use in mathematics is rare. Client-driven projects represent an authentic connection between some standard mathematics content and the world beyond the classroom, but their use as tools for teaching mathematics also raises many curricular and pedagogical issues. We discuss, in limited evaluation, how service-learning seem to have a positive impact on students' attitudes and motivation. We share our five-year team teaching experience of several facets of service-learning in teaching a non-major first-year mathematics course including, the acquiring of projects, the dynamics of the teams, assessment of students' work, the use of technology, and lessons we have learned in dealing with the practice of mathematics outside of academia. Furthermore, we briefly discuss projects used in our team-teaching over five years along with the mathematical techniques applied in each project. (Received July 16, 2010)

1067-K1-855 **Melinda S Schulteis*** (melinda.schulteis@cui.edu), 1530 Concordia West, Irvine, CA 92612-3203. *Serving Hope- How to build service-learning into your non-major mathematics courses to benefit the local community.*

Service learning has become a major focus at our university. In this session, we will describe how we have incorporated a service learning component into our non-major mathematics courses. We will explain the expectations for the service-learning experience events as well as describe rubrics for journals and oral presentations which help students reflect on the service-learning taking place. At Concordia University, Irvine we have established a relationship with the Village of Hope- a local non-profit organization designed to help homeless families transition to a self-sufficient status via temporary housing and training programs. In particular we provide tutoring for the elementary aged children. We will describe some of the challenges and considerations, on and off campus, required in setting up such an opportunity (the Village of Hope is the third organization we have worked with), as well as review some student reflections. This community service-learning opportunity is highlighted as one of the reasons Concordia has received the Presidential Higher Education Award for Community Service the past three years. (Received September 15, 2010)

1067-K1-913 **Tim Chartier*** (tichartier@davidson.edu), Davidson College, Department of Mathematics, P.O. Box 6908, Davidson, NC 28035. *A Model for the Community.*

Service-learning offers unique educational opportunities for students to apply their learning to issues of community interest. This talk will discuss a service-learning project used in a discrete math modeling course. The course teaches such topics as Monte Carlo simulation, queuing theory, Markov Chains, and optimization. The capstone group project requires students to create a mathematical model for a problem posed by a local non-profit organization. Topics included designing the layout of a parking lot for a local food pantry and assigning elementary students into practicum groups according to scheduling constraints and indicated interests for a local elementary school. The final model and recommendations from it were presented in a public poster session and in a paper. This talk will discuss how such project topics were collected and integrated into the course. (Received September 16, 2010)

1067-K1-1296 **Debra L. Hydorn*** (dhydorn@umw.edu), 1301 College Avenue, Fredericksburg, VA 22401. *Community Service-Learning in Mathematics: Models for Course Design.*

Service-learning provides a useful way for students to experience both the application and appreciation of mathematics. Effective service learning, however, depends on several factors and can be implemented according to a variety of models. In this session, seven models for incorporating service-learning in mathematics courses will be presented along with example courses. In addition, principles for good service-learning practice will also be discussed as a means for assessing the quality of a service component or activity. (Received September 20, 2010)

1067-K1-1320 **B. Carrigan*** (bac0004@auburn.edu), Auburn University, Parker Hall, Auburn, AL 36849, and **C. Carrigan**, **B. Kozak** and **C. Rodger**. *Northern Territory Maths Camp.*

In June 2010, a team of three graduate students and a professor from Auburn University traveled to the Northern Territory of Australia to partner with a professor from Charles Darwin University and local teachers to provide weekend math camps for around 70 students aged 12 to 15. The graduate students were charged with developing inquiry based problems from well-known theorems involving advanced mathematical principles, which were tailored to enable the students to investigate finite and abstract examples that would hopefully lead them to conjecture the general results. Each group of students was guided using both open ended questioning and access to appropriate manipulatives. The students' progress and development of problem solving was exemplified through their careful construction of statements as they discussed their findings. At the conclusion of the camp, the team from Auburn University presented abstract solutions for the claims made by the students. A report on these activities will be presented. (Received September 20, 2010)

1067-K1-1402 **Ethan Berkove*** (berkovee@lafayette.edu), Department of Mathematics, Lafayette College, Easton, PA 18042. *A Service Project in a Capstone Modeling Course.*

This talk describes a successful service-learning project incorporated into a senior level capstone course in mathematical modeling at Lafayette College. In the last month of the course, students investigated ways to increase the self-sufficiency of a local not-for-profit organization offering loans to area companies. Students presented their findings to representatives of the organization as part of their final report. This talk will focus on how this project was developed, how it was incorporated into the course, student reactions, and lessons learned. (Received September 20, 2010)

1067-K1-1465 **Charles R. Hadlock*** (chadlock@bentley.edu). *Opportunities and Challenges in Incorporating Service-Learning in Mathematical Sciences Programs.*

Except for statistics and mathematics education, most math faculty would probably be hard pressed to point to good and convenient opportunities to incorporate service-learning in the math curriculum. To be sure, there are many challenges associated with arranging projects that make a meaningful contribution to the learning process and that are practical for a teacher to set up and supervise. Several years ago, the MAA asked me to put together a book on service-learning, as math had been distinctly absent from a series on service-learning in the disciplines that had been published by AAHE. As the result of a broad survey of the community and written contributions from many inspiring and energetic colleagues, this book was published by the MAA in 2005 (http://www.maa.org/pubs/hadlock/index.html). This talk will emphasize some of the largely untapped opportunities I see in mathematical service-learning, and it will also address the larger institutional context and how this can help faculty find the right model for implementation. (Received September 21, 2010)

1067-K1-1507 **Rachelle M. Ankney*** (ankney@gmail.com), Chicago, IL. *Just Math: Learning about Justice with Math vs. Doing Justice with Math.* Preliminary report.

Two general-education math courses focus on social justice issues in housing finances, census data, and transportation. One class *learns about* injustices, and the other class *works for* justice while they learn the material. Is the mathematical learning affected? Are the classes any different regarding performance in, retention of, or engagement with the mathematics? See what we discovered. (Received September 21, 2010)

1067-K1-1524 **Brad Bailey*** (bbailey@northgeorgia.edu), 82 College Circle, Dahlonega, 30597, and **Robb Sinn** (rsinn@northgeorgia.edu), 82 College Circle, Dahlonega, 30597. *Real Data & Service Learning Projects in Statistics.*

The speakers will describe three statistics courses all of which include some service learning projects using real data. These three courses are: an introductory course for non-math majors, a course in probability and statistics for math/science majors, and an advanced statistics course. During the talk we will briefly give more details on these classes, including how the courses were structured (or re-structured) to accommodate the service learning components. In addition, we will describe some of the projects that students have completed in these courses and give the audience suggestions for using similar service learning projects in their own statistics courses. Lastly, we will give examples of student feedback regarding these projects, which has been positive. Indeed, many students say that participating in these projects not only helped deepen their understanding of statistics but made them feel like they were contributing to something important. (Received September 21, 2010)

1067-K1-2037 **Karl-Dieter Crisman*** (karl.crisman@gordon.edu). *Mathematical and Moral Development Through Service-Learning.* Preliminary report.

One goal of providing service-learning opportunities is to help students connect mathematics study with the rest of their lives. Given that much service-learning is motivated by concerns of a broadly moral nature, it is natural to ask students to specifically reflect on this aspect of their service.

This talk reports on this at our college, where student self-reports overwhelmingly did not just describe the service as having been mathematically helpful or a good thing to do, but as having given impetus to (broadly speaking) deeper moral reflection and formation. Reflecting on this placed their service in a personal (not just community) context, and provided a chance for students to explore their own ideas about why or how they are serving.

The context for this is a service-learning opportunity (tutoring local urban high school students in related course material) in three separate offerings of basic calculus courses over the last four years. Students self-selected into this (one of several options) for a semester-long project. (Received September 22, 2010)

1067-K1-2137 **Karen Batt Stanish*** (kstanish@keene.edu), 229 Main St, Keene, NH 03435-2010. *Serve While You Learn: A Quantitative Literacy Course.* Preliminary report.

How can we use service-learning to motive general education students to improve their quantitative literacy? This talk will describe the use of service-learning in a general education quantitative literacy course and detail its impact on student learning and level of student engagement. In this course, students analyzed data from various on-campus groups with service missions and reported the results of their analysis in both written reports and oral presentations. (Received September 22, 2010)

1067-K1-2164 **Benjamin Galluzzo*** (bjgalluzzo@ship.edu), Department of Mathematics, Shippensburg University, Shippensburg, PA 17257. *Disaster Modeling – Beyond the Numbers.*

Due to the Gulf Oil Spill, the U.S. is facing its largest environmental catastrophe ever. The uncertain future of the region's many coastal ecosystems in addition to the economic impact of successive disasters lends itself to a variety of mathematical modeling problems. Unfortunately, what we are able to learn about the scale and reality of the oil spill and its impact has been minimal; especially when we are often provided with numbers that give us very little insight into their actual meaning. This past fall, over 50 Shippensburg University students majoring in a wide variety of disciplines, traveled to the Mississippi Gulf Coast to see first-hand what had happened and to provide help with ongoing cleanup efforts. The fall mathematical modeling course used the Deepwater Horizon spill as a common theme for class activities and had some members of the class go on the Gulf trip. Upon returning to the classroom, the traveler's reports made many groups rethink and eventually change their models. In this talk, we will discuss the value of qualitative perspective in developing quantitative models in a mathematical modeling class. (Received September 22, 2010)

Innovative and Effective Ways to Teach Linear Algebra

1067-L1-328 **Paul Raymond Bouthellier*** (pbouthe@pitt.edu), 504 East Main Street, Titusville, PA 16354. *Rotations via Quaternions and Interpolation.*

In computer animations cameras need to move and rotate through a scene and rotate about their own axes as they move through the scene. In this talk we shall look at quaternions for rotating objects in 3-dimensional space. We shall create a camera which can rotate about a scene as well as rotate about its own axes by taking a product of quaternions. Quaternion interpolation and back-face culling via cross and dot products will also be discussed. The above concepts will be illustrated with movies generated by graphics programs such as Flash, Poser, Swift3D, Studio 3D Max, Maya, and Carrara. (Received August 23, 2010)

1067-L1-413 **David Strong*** (david.strong@pepperdine.edu), 24255 Pacific Coast Highway, Malibu, CA 91214. *A nickel and dime example for motivating a variety of linear algebra concepts.*

I will discuss an example involving coins that I use the first day of class to motivate several basic concepts that arise in linear algebra. The example is simple and naturally leads to students discovering most of the ideas on their own, supplemented by a bit of direction and observation from me. (Received September 01, 2010)

1067-L1-459 **Karsten K. Schmidt*** (kschmidt@fh-sm.de), Faculty of Business and Economics, Schmalkalden University of Applied Sciences, Blechhammer, 98574 Schmalkalden, Germany. *An Evaluation of Students' Experiences in a Technology-based Linear Algebra Course.* Preliminary report.

The Schmalkalden University Faculty of Business and Economics has changed its introductory linear algebra course: it is no longer given in a traditional classroom setting (using blackboard, overhead projector, and pocket calculators) but in the PC lab (one or two students in front of a PC, teacher's PC connected to a projector), where a Computer Algebra System (CAS) is available throughout the semester. The faculty's CAS license also covers the private PCs of the students such that they can use the software at no charge at home as long as they are enrolled at our faculty. Students also have access to the CAS during the final exam in the PC lab (here, naturally, only one student per PC). While the course and the examination have taken place in the PC lab for a number of years, it will be the first time that a series of surveys will be carried out (throughout the current academic year) to find out if the students prefer a traditional or a technology-based course, and how well they cope with this technology. Preliminary results from the first survey (October 2010) will be presented. (Received September 05, 2010)

1067-L1-868 **Aldo R Maldonado*** (aldo.maldonado@gmail.com), 15300 Cadoz Dr., Austin, TX 78728. *I am the Alpha, I am the Omega.*

I will describe the use of Wolphram's Alpha software in a linear algebra course for Computer Science majors at Park University. Park University caters to non-traditional students. Most of the students takine this course are already employed in the Computer science field and are always looking for innovative ways to do computations. Alpha provides a very reasonable alternative. This course takes place at a satellite campus in Austin, Texas. Advantages, disadvantages and examples will be emphasized. (Received September 15, 2010)

1067-L1-971 **Kim Kyung-Won*** (kwkim@skku.edu), Dept. of Mathematics, Sunkyunkwan University, Suwon, Jangan Gu 440-746, South Korea, and **Lee Sang-Gu** (sglee@skku.edu), Dept. of Mathematics, Sunkyunkwan University, Suwon, Jangan Gu 440-746, South Korea. *What Educational Portal of International Linear Algebra Society(ILAS) can do?*

We introduce updated ILAS Education homepage as a educational portal site for Linear algebra. We will show what are the new features of it, and discuss what these gathered information on teaching of linear algebra can do for all of us. (Received September 17, 2010)

1067-L1-972 **Lee Sage-Gu*** (sglee@skku.edu), Dept. of Mathematics, Sunkyunkwan University, Suwon, Jangan Gu 440-746, South Korea, and **Kim Kyung-Won** (kwkim@skku.edu), Dept. of Mathematics, Sunkyunkwan University, Suwon, Jangan Gu 440-746, South Korea. *Mobile Sage-Math for Linear Algebra and its Application.*

With the innovation of information and communication technologies, many tools have appeared and been adapted for educational purposes. Mathematical tools have long held an important place in classrooms. Sage-Math has efficient features which utilize the internet and can handle most mathematical problems, including linear algebra, algebra, combinatorics, numerical mathematics and calculus. In this talk, we introduce a mobile infrastructure of Sage-Math in a new learning environment with smartphones. We will show our App for learning of Linear algebra. (Received September 17, 2010)

1067-L1-1379 **Steven J Leon*** (sleon@umassd.edu), Mathematics Department, UMass Dartmouth, 285 Old Westport Road, Dartmouth, MA 02747. *The Second Undergraduate Level Course in Linear Algebra.* Preliminary report.

In this talk we will review briefly the recommendations made twenty years ago by the NSF sponsored Linear Algebra Corriculum Study Group. We will discuss what topics should be covered in undergraduate linear algebra courses and give reasons why we believe a second course in linear algebra should be required for all mathematics majors. The speaker will outline a number of alternatives for possible second courses. He will describe one such course where students work together in teams on projects and apply linear algebra to problems in areas such as digital imaging, computer animation, and coordinate metrology. Some of these projects may involve original undergraduate level research. (Received September 20, 2010)

1067-L1-1430 **Megan J Wawro*** (megan.wawro@gmail.com), 6475 Alvarado Road, Suite 206, San Diego, CA 92120-5013, and **Michelle Zandieh** (zandii@asu.edu). *Detailing an Innovative, Student-Centered Instructional Sequence that Builds from Students' Intuitive Understandings of Vector to Formal Definitions of Span and Linear Dependence.*

We present an innovative instructional sequence for an introductory linear algebra course that supports students' reinvention of the concepts of span, linear dependence, and linear independence. The problem setting of the instructional sequence, known as The Magic Carpet Ride Problem, builds from students' previous mathematical and life experiences. Through this, the course begins by focusing on vectors and vector equations, their algebraic and geometric representations, and properties of sets of vectors. Furthermore, during students' own process of developing understanding of the objects of linear algebra (namely, vectors and vector equations), they see-for themselves-a need for powerful and efficient solution techniques, such as Gaussian elimination. Finally, we repeatedly see evidence of how powerful a metaphor the Magic Carpet Ride problem is for students throughout the duration of the semester. During the presentation we will: a) present the instructional sequence and samples of student work; b) discuss how this sequence fosters the development of formal ways of reasoning about the objects of linear algebra and intellectual need for sophisticated solution techniques; and c) exemplify the power of this sequence as students encounter new content during the semester. (Received September 21, 2010)

1067-L1-1459 **Murphy Waggoner*** (murphy.waggoner@simpson.edu), 701 N C Street, Indianola, IA 50125. *Ray-based Tomography: An application for linear algebra.*

Ray-based tomography is a way to investigate the body (CT scans), the earth (seismic data) and other hidden structures. Rays are passed through an object and travel time recorded. Using discretization, a system of equations is then solved for the "slowness" factors of the regions of the structure. In this talk, I will explain how the systems of equations are developed and give examples of both forward and inverse problems for a linear algebra course, with emphasis on underdetermined systems. (Received September 21, 2010)

1067-L1-1523 **Thomas W Polaski*** (polaskit@winthrop.edu), Department of Mathematics, Winthrop University, Rock Hill, SC 29733. *Visualizing Discrete Dynamical Systems.*

Discrete dynamical systems of the form $\mathbf{x}_{k+1} = A\mathbf{x}_k$ are often encountered in the first undergraduate linear algebra course and are used in models from ecology and engineering. The eigenvalues and eigenvectors of A are the key to understanding the long-term behavior of these systems. When A is a 2×2 matrix, one can gain geometric information about the dynamical system by plotting a trajectory, which is an initial point $\mathbf{x}_0$ together with its iterates $\mathbf{x}_1, \mathbf{x}_2, \ldots$. This talk will demonstrate programs in *Mathematica* that allow students to create a matrix A with their choice of real or complex eigenvalues and to animate trajectories of the resulting dynamical system from multiple initial points. The programs also allow students to work with a matrix with randomly chosen eigenvectors so as to discover the importance of the directions of the eigenvectors when the eigenvalues of A are real. (Received September 21, 2010)

1067-L1-1615 **Robert L. Sachs*** (rsachs@gmu.edu), MSN 3F2, Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030. *A geometric view of orthogonal diagonalization of symmetric matrices.*

The orthogonal diagonalization of symmetric matrices is developed geometrically using a min-max principle. The 2x2 case leads to the higher dimensional cases involving constrained minimizers of a quadratic function. A geometric description of why the gradient vector field is radial at such points is extremely accessible to students.
(Received September 21, 2010)

1067-L1-1877 **Jason Grout*** (jason.grout@drake.edu), Math & Computer Science Dept., Drake University, 2507 University Ave, Des Moines, IA 50311. *Eigenvalues first? Teaching linear algebra with computation, then application, then theory.* Preliminary report.

I will describe an experience teaching sophomore-level linear algebra in which rref, determinants, coordinates, eigenvalues/eigenvectors, and other computations were introduced in the first few weeks, followed by selected real-world applications of linear algebra. After students had practiced many fundamental computations in the course and had seen motivating examples of linear algebra, we delved deeper into theory (vector spaces, etc.). Goals for this approach included (1) students developing intuition from concrete computation before a focus on theory and (2) repetition and emphasis of fundamental concepts (e.g., rref, determinants, coordinates, eigenvalues/eigenvectors, etc.) throughout the entire course.

We followed a revised version of Ben Woodruff's free open-source textbook (http://artsci.drake.edu/grout/doku.php/books#linear_algebra, licensed under the Creative Commons CC-by-sa license). We also used Sage (http://sagemath.org) for computations. (Received September 22, 2010)

1067-L1-2079 **Robert Talbert*** (rtalbert@franklincollege.edu), Department of Mathematics and Computing, Franklin College, 101 Branigin Boulevard, Franklin, IN 46131. *Inverting the Linear Algebra Classroom.*

Linear Algebra is a difficult course for some students because it involves significant amounts of both conceptual and mechanical knowledge. In a traditional classroom structure, this knowledge is initially *transmitted* to students through lectures, and then the knowledge is *assimilated* by students through group work, problem sets, and the like. The flaw in this arrangement is that the activity that is simplest from a cognitive standpoint – transmission – takes up the majority of class time, while the much more complex assimilation phase occurs primarily outside of class. Hence, students often find themselves working on tasks that require the greatest amount of instructor intervention precisely when that intervention is least effectively available. One way to ameliorate this problem is to use an *inverted classroom* structure, in which the transmission phase takes place outside of class, leaving class time free to be used on activities in the assimilation phase with direct instructor supervision. In this talk, we examine some ways the inverted classroom structure has been implemented in linear algebra through the use of screencasting and activities involving Wolfram|Alpha and MATLAB. (Received September 22, 2010)

1067-L1-2094 **Steven M Hetzler*** (smhetzler@salisbury.edu), 1101 Camden Ave., Salisbury University, Department of Math and CS, Salisbury, MD 21801. *Interviews to Assess Vocabulary and Understanding.* Preliminary report.

This paper outlines the objectives, process, and results of using brief interviews as a component of exams in a linear algebra course. The primary objective is to measure students' ability to use vocabulary appropriately in spoken dialogue, their familiarity with fundamental examples of important concepts, and their impromptu deductive reasoning abilities. This is also intended as formative evaluation; it is expected that students will learn some interesting mathematics or develop better reasoning and speaking skills from the experience. In the week following an in-class exam, students meet with the professor in his office for a five to ten minute conversation. There is a short set of questions each student is asked. If necessary, the instructor will vary the script slightly, providing guidance only as needed to keep the conversation moving. For instance, students might be asked to provide an example of a 3-d vector that is not in the span of a set of vectors. Then, the student will be asked to demonstrate that the example meets the intended criterion. Other samples will be provided in the talk, as well as results from using this approach in linear algebra and elementary real analysis. (Received September 22, 2010)

Journals and Portfolios: Tools in Learning Mathematics?

1067-M1-520 **Penelope Dunham*** (pdunham@muhlenberg.edu), Dept. of Mathematics and Computer Science, 2400 W. Chew St., Allentown, PA 18104. *Proof Writing and Portfolios in a Bridge Course.*

As mathematics majors move from calculus into more abstract courses, they face the task of learning to read and understand proofs. Learning to produce their own proofs is an even bigger challenge for most students. I have found that portfolios are useful tools that help students develop their proof-writing skills and that give me an effective means of assessing student progress. Through portfolios, students can revise proofs, polish their writing, document their growth, and ultimately produce well-written and effective arguments. In this talk, I'll describe how I use proof portfolios as a major component in a 200-level "transition" course. The talk will provide details about initial instructions to students, the monitoring of student progress, the assessment process, and the role of portfolios in the final course grade. I'll conclude with student comments about the value of creating a portfolio and its effects on their mathematical understanding and writing. (Received September 08, 2010)

1067-M1-1916 **Carrie A Campbell*** (aicarriecampbell@gmail.com). *Learning Logs in College Algebra: A Window to Student Perceptions of Learning Progress and Student Engagement.*

This investigation studied student perceptions of learning and student engagement in college algebra. The study spanned two semesters and included three groups of students. The first group was presented with algebraic procedural examples and assessments without context. The second group was presented with algebraic class examples in contexts related to student majors and hobbies, but assessments without context. The third group was presented with class examples in contexts related to student majors and hobbies and also assessments with context.

Learning logs or student journals in this investigation were used to study student perceptions of learning. Student comments regarding learning progress were analyzed qualitatively, using grounded theory. Participation in completing learning logs also provided a measure of student engagement. Students in higher context groups had higher participation rates, Group 3 having 65% participation, Group 2 at 58% average participation, and Group 1 only averaging 36% of students returning learning logs. (Received September 22, 2010)

1067-M1-2263 **G Maria Fung*** (mfung@worcester.edu), Mathematics Department, 486 Chandler Street, Worcester State University, Worcester, MA 01602. *Using Journals and Portfolios in a Modern Geometry Course.* Preliminary report.

Students enrolled in an upper level geometry course submit weekly journals describing all their geometric experiences. Narratives include description of difficulties and insights, problems they or their peers presented, or work on exploratory labs. At the end of the semester, students hand in a portfolio of their best work in the course, from proofs they generated to final project presentations. (Received September 22, 2010)

The Mathematical Foundations for the Quantitative Disciplines

1067-N1-393 **David G Taylor*** (taylor@roanoke.edu), Roanoke College, MCSP Department, 221 College Lane, Salem, VA 24153. *Faculty and Student Support for Quantitative Reasoning and How to Make it Count.*

Roanoke College recently introduced a new general education curriculum designed to emphasize three areas of critical thinking: writing, oral communication, and quantitative reasoning. While the former two are prevalent, adding quantitative reasoning in many courses (which may not be taught by mathematics or science faculty) across the curriculum exposes students to the essence of reasoning quantitatively; this addition will require focused faculty development and student support. In this talk, I will present several solutions and my first-hand thoughts to these needs, as well as invite audience feedback and ideas. (Received August 31, 2010)

1067-N1-586 **Lisa S Yocco*** (lisay@georgiasouthern.edu), P.O. Box 8093, Statesboro, GA 30458. *The Right Stuff: Are We Teaching It In College Algebra?*

The Right Stuff: Appropriate Mathematics for All Students was an AMATYC project funded by the National Science Foundation. The project promotes a redesigned college algebra course that engages students in data modeling, effectively uses technology, equips students with strong problem solving skills, increases critical thinking skills, and enhances quantitative literacy. Mathematics has traditionally been taught using "skill and drill" methods, which often leaves students bored, uninterested, and distasteful of math. An approach incorporating data analysis, modeling, and technology makes College Algebra relevant, refreshing, and interesting. As a result, faculty are preparing students mathematically for their majors, future careers, and life. Real data problems will be explored that illustrate how applications from the management, life, and social sciences can be used to teach algebra concepts and skills. Solution methods include modeling, graphical solution, and matrices using the TI-84 Plus and the TI-Nspire calculator. Modeling and other algebra topics with Excel will be demonstrated. Problems to be illustrated include life expectancy, home loans, male vs. female earnings, and cost-benefit. (Received September 10, 2010)

1067-N1-1093 **Marko Kranjc*** (M-Kranjc@wiu.edu), Department of Mathematics, Western Illinois University, 1 University Circle, Macomb, IL 61455. *Ways to teach meaningful modeling in algebra-based courses.* Preliminary report.

We will discuss possible approaches to teaching algebra-based courses at pre calculus levels. In particular, our experience teaching a particular course with the use of spreadsheets will be described. We will explain how meaningful models of varying complexities can be introduced and understood, starting with simple exponential models and leading to models of the predator-prey type. We will discuss observed advantages and disadvantages. We will compare this course with a similar course that was taught with the use of graphic calculators. (Received September 18, 2010)

1067-N1-1391 **D Scott Dillery*** (dillerys@lindsey.edu), 210 Lindsey Wilson Street, Columbia, KY 42718. *A year's experience with implementing a data modeling based course at the College Algebra level.*

Functions and Algebra is in its second year of the general education curriculum at Lindsey Wilson College. Content familiarizes students with standard mathematics functions. These include polynomial, rational, exponential, logarithmic and trigonometric functions. The course uses a data modeling approach to introduce and to utilize the functions. There is a large emphasis on the algebra needed to transform data to fit linear models and little emphasis on factoring algebraic expressions. Technology is utilized to perform matrix arithmetic to solve interpolation and least squares problems. During the fall semester of 2009, student performance matched that of general education courses in other disciplines. This was not the case, however, in the spring of 2010. Achievement was far below other courses. In this talk the author will outline the curriculum highlighting example problems taken from practitioners, explain the motivation for the curriculum, summarize success rates, speak to tutoring issues, relay thoughts on placement and discuss reluctance of faculty. (Received September 20, 2010)

1067-N1-1619 **Suzanne I Doree*** (doree@augsburg.edu). *Not your mother's college algebra course – rethinking how we prepare students for quantitative reasoning across the disciplines.* Preliminary report.

Many of today's courses in college algebra were designed to prepare students for pre-calculus and, hopefully, calculus. Most of today's students in a college algebra course have other plans in mind. While a small percentage do continue to pre-calculus, and an even smaller percentage persist to calculus, the majority of college algebra students are preparing for courses in a range of quantitative disciplines – sciences, business or economics, statistics, computer science, and other mathematical sciences – and to become quantitatively literate citizens in today's society. This mismatch has led many of us to rethink both what and how we teach college algebra, often choosing to focus on more applied, context-based problems that will appeal to and better prepare this broad audience. For the past seventeen years we have taught a highly successful, 100% contextual, modeling-based "Applied Algebra" course to diverse learners at Augsburg College. This talk will overview the audience and content of this novel course and offer several specific examples of how the approach to content differs from the traditional approach. (Received September 21, 2010)

1067-N1-1625 **Richard D. West*** (rwest@fmarion.edu), 3586 W Hampton Pointe Dr, Florence, SC 29501-8516. *Discrete Dynamical Modeling for Freshmen.*

Discrete Dynamical Systems (or difference equations) is rich with real world applications. I originally used this material as a "bridge" course for students transferring to Francis Marion University, which has a general education mathematics requirement of two courses. Now I am using Discrete Dynamical Systems in a freshman-level Discrete Dynamical Modeling course. To get this course approved I proposed it for majors not interested in pursuing calculus. The calculus students at Francis Marion are invariably required to take trigonometry or precalculus prior to taking calculus. This course enables students not interested in calculus to fulfill their education requirements with Discrete Dynamical Modeling and Probability & Statistics, useful courses for all citizens. Discrete Dynamical Modeling currently has four projects that highlight personal finance, institutional finance, pollution, and population dynamics. The modeling required is intuitive, and iteration gives answers to many problems where answers were not accessible to freshmen. Further, I find that Discrete Dynamical Systems gives insights into linear and exponential functions that were difficult to motivate with continuous mathematics. There are other benefits that I will elaborate on in my talk. (Received September 21, 2010)

1067-N1-1899 **Sheldon P. Gordon*** (gordonsp@farmingdale.edu), 61 Cedar Road, E. Northport, NY 11731. *Integrating Statistics into College Algebra: Providing the Mathematics that Students Need.*

Most students take College Algebra as a requirement from other disciplines. Yet, most of those disciplines strongly recommend that students see more statistics, particularly for the lab and other data-intensive fields. This presentation will focus on ways to integrate statistical ideas and methods throughout a College Algebra course to better meet the needs of the students and the other disciplines. The goal is to have the statistical concepts and methods arise as natural applications of college algebra ideas, so that the course becomes a natural mesh of the two rather than a disconnected add-on to a college algebra course. This approach is also in the spirit of the MAA's initiative to change the focus of college algebra and related courses. (Received September 22, 2010)

1067-N1-2044 **Jill F McGowan*** (jmcgowan@howard.edu), 407 Gilmoure Dr., Silver Spring, MD 20901. *Using Global Warming to Teach College Algebra: Preliminary Report.*

Does the use of an interdisciplinary topic to motivate the study of College Algebra produce better results than a more traditional lecture approach? Two professors at Howard University attempted to introduce several of the concepts taught in College Algebra by linking them to modeling problems that arise in the investigation of global warming. Linear functions were used to model temperature changes in several cities; exponential functions, to model the increase in CO2 levels in the atmosphere. These courses were compared with courses taught in a more traditional style by other colleagues, and by the same faculty in former semesters. Data gathered will include course grades and course evaluations. (Received September 22, 2010)

Mathematics Experiences in Business, Industry, and Government

1067-O1-129 **Petronela Radu*** (pradu@math.unl.edu), Lincoln, NE 68588, and **Stephen Hartke**. *Math in the City: A hands-on learning experience in mathematical modeling.*

Math in the City is an interdisciplinary course in which students engage in a hands-on learning experience using mathematical modeling to understand current major societal issues of local and national interest. The course is run in collaboration with local businesses and research centers with students creating and analyzing models based on real data. In this talk I will focus on the structure and development of the course, the educational benefits, and also discuss some of the challenges that we have encountered. The course will be further developed while supported by a STEM (former CCLI) NSF award and it will be disseminated to other colleges and universities. (Received July 26, 2010)

1067-O1-439 **James H Fife*** (jfife@ets.org), Educational Testing Service, Princeton, NJ 08541. *Improving the performance of open-ended mathematics questions.*

Two of my colleagues and I conducted a research study in which selected poorly-performing open-ended mathematics questions were revised in various ways to see if the revisions could remove non-construct-related difficulty while preserving construct-related difficulty and preserving the skills and abilities that the questions were originally designed to measure. For some of the questions, we created parallel versions, carefully varying different aspects of the language. The questions were then piloted on a sample of about 500 middle-school students. We found some interesting differences in student performance among the various versions. For example, one question asked students to give both an equation and an explanation that describes the relationship between four proportional variables. In one version we asked the equation question first, and in the other version we asked the explanation question first. We found that, while the order in which the questions were asked made no difference in the proportion of students who answered the questions correctly, it could make some difference in the type of error a student who answered incorrectly might make. In this talk, I will discuss this and our other findings. (Received September 03, 2010)

1067-O1-562 **William P. Fox*** (wpfox@nps.edu), 489 Dyer Rd, Room 103 F, Naval Postgraduate School, Monterey, CA 93943, and **Michael Minutas** and **John Binstock**. *Building Models and a Methodology for Using Technologies to Detect Suicide Bombers.*

Preliminary Report: Terrorist use human-born Improvised Explosive Devices against public and military persons. These undetected suicide bombers enter crowded public areas in order to detonate the IED, inflicting lethal damage to the surrounding individuals. Currently, there are no detection systems that can identify suicide bombers at adequate standoff distances. We develop models and a methodology that examine current technologies to increase the probability of identifying a suicide bomber. (Received September 09, 2010)

1067-O1-713 **Candice Rockell Gerstner*** (`crockell@odu.edu`), Department of Mathematics and Statistics, Old Dominion University, Norfolk, VA 23529, and **John Tweed**, Old Dominion University. *Updates on a New Green's Function Code for Radiation Transport.*

In the future, astronauts will be sent into space for longer durations of time compared to previous missions. Due to their increased risk of exposure to high charge and energy (HZE) ions from deep space, there has been an increased need for an efficient HZE transport code to accurately model this radiation. Consequently, a new code is currently under development. It is a three dimensional deterministic code based on the Green's function technique. This presentation will discuss the progress made toward the development of this code. (Received September 13, 2010)

1067-O1-1318 **Mike P O'Leary*** (`moleary@towson.edu`), Department of Mathematics, Towson University, 8000 York Road, Towson, MD 21252. *Patterns in criminal offender distance decay.*

The geographic profiling problem in criminology is the problem of estimating the location of the home base of a serial offender based on the known locations of the criminal's offense sites. This is an operational problem of some importance for law enforcement agencies throughout the country.

Fundamental to any mathematical approach to this problem is an understanding of how offenders select targets, and one important component is the distance decay behavior of the offender. This curve gives the fraction of offenses that occur at a given distance from the offender's home base. Despite being well studied, there is no consensus as to the best mathematical form of the distance decay curve.

By appropriately rescaling the problem, we shall show that a simple a priori argument lead to a predicted distance decay curve that is a close match for the observed distance decay curves. We shall discuss these results and explain their significance for the geographic profiling problem. (Received September 20, 2010)

1067-O1-1401 **Vincent E Dimiceli*** (`vdimiceli@oru.edu`), Engineering, Comp. Science, Physics and Math, 7777 S Lewis Ave, Tulsa, OK 74171, and **Steven F Piltz**. *Estimation of Black Globe Temperature for Calculation of the WBGT Index.* Preliminary report.

– The wet bulb globe temperature (WBGT) index is used in industry, sports and other areas to indicate the heat stress level for humans and animals. One of the values needed to calculate the WBGT index is the black globe temperature. The black globe temperature is measured using a WBGT instrument which includes a black globe with a thermometer inserted in the center. However, the WBGT instrument can be costly and many of these instruments may be needed to get measurements in many locations. The authors have derived a formula to estimate the black globe temperature using readily available data collected by the National Weather Service (NWS). The formula was derived from a formula suggested by Kuehn (1970), which was based on heat transfer theory. The resulting equation was a fourth degree polynomial in terms of the black globe temperature. It was determined that the fourth degree polynomial in terms of the black globe temperature can be very accurately approximated using a linear expression in terms of black globe temperature. Some preliminary tests indicate accuracy within 0.5 –. (Received September 20, 2010)

1067-O1-1407 **Carl L Moravitz*** (`moravitz@us.ibm.com`), 8921 Garden Stone Lane, Fairfax, VA 22031. *The Strategic Use of Analytics in Government Is A Powerful Resource In Achieving Federal Missions.*

Budgeting optimizes acquisitions of the right resources at the right place at the right time to ensure they are consumed at the right rate to satisfy identified demand. Spending for everything-frontline production of products, defense mobilization, biomedical research, education"and revenues from every source-are all reflected, recorded, and battled over in numbers. The sum of those numbers, and who gets how much, is all wrapped up in Government budgeting world. How are successful managers dealing with "information overload?" One technique is through strategic use of analytics. "Analytics" is the extensive use of data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions. When used together, analytics and fact-based decision-making can make a powerful contribution to the success of a wide range of government missions. Government has had real success in the implementation of data analytics in areas of health care fraud, military troop forecasts and population ratios, tax collection and debt management, and intelligence assessments. Breakthroughs in technology, modeling, and optimization sciences make it possible to do more, and focus intensively on results, metrics, and cost management. (Received September 20, 2010)

1067-O1-2022 **Timothy D Andersen*** (tim@va.wagner.com), 2 Eaton St., Suite 500, Hampton, VA 23669, and **C Allen Butler** (allen.butler@va.wagner.com), 2 Eaton St., Suite 500, Hampton, VA 23669. *Bayesian Inference for Rapid Social Networking Analysis.*

One approach to social network analysis models the network as a weighted graph, G=(V,E) with weights on either the vertices, the edges, or both. In a terrorist network there are levels of trust and complex relationships involving family ties, shared history, and natural abilities of the members that cannot be reduced to a single number. E.g., a cell leader may trust one member to carry packages but not information, another may be trusted with money; some may be allowed more information than others because of kinship ties; or assigned specific tasks because of abilities. All of these data are gathered as evidence with some uncertainty since any evidence is potentially false. Synthesizing data into useful details about how each relationship works is a complex task. In this talk we show how Bayesian networks are applied to making knowledge inferences about uncertain data. We show how they can infer the answers to a variety of questions about what is true about each node or relationship and to give a confidence score for the answer automatically. This versatility is essential to understand how relationships work at a fundamental level. (Received September 22, 2010)

1067-O1-2087 **Sonja Sandberg*** (ssandberg@framingham.edu) and **Steven Anderson**. *The US blood supply, bioterrorism and mathematics.*

Concern about bioterrorism has abated as worry about the economy has taken over people's thoughts. Nonetheless, bioterrorism continues to be a real threat. In the case of a smallpox bioterrorism event, the initial focus would be on minimizing the number of illnesses and deaths. A mass vaccination program would likely be mounted as soon as possible after the threat is detected and the federal government is now stockpiling smallpox vaccine for this purpose. One consequence of a vaccination program is the loss of blood donors due to a deferral period following vaccination.

A mathematical model was developed to explore various scenarios to predict the impact of a vaccination campaign on the blood supply. Campaign lengths of 10, 21, 30 and 45 days were considered. Intervention strategies of doubling blood donations for 30 days and/or eliminating elective uses of blood were modeled. The computer simulations indicate that a mass smallpox vaccination campaign could have a serious deleterious effect on the blood supply. Implementing both interventions could ensure that there is enough blood for critical, life-threatening needs, while implementing only one would be inadequate. The results could be used to preserve essential medical services during a health crisis involving smallpox. (Received September 22, 2010)

The Mathematics of Games and Puzzles

1067-P1-77 **David E Molnar***, Felician College Dept. of Mathematics, 223 Montross Ave., Rutherford, NJ 07070-1612. *Connection Games and Sperner's Lemma.*

The game of **Hex** is the most well-known of the great iceberg of *connection games*. Hex's cousin **The Game of Y** is played on a triangular board, with the goal to connect all three sides. A beautiful proof using Sperner's Lemma (known for its association with the Brouwer fixed-point theorem) shows that the game cannot end in a draw. From this the fact that Hex cannot end in a draw follows as a corollary.

In early 2008, Mark Steere published two new connection games, **Atoll** and **Begird**, which generalize Hex and Y, respectively. Atoll has received some attention through online play and a feature in *Games* magazine. Atoll is played on a grid of hexagons surrounded by eight 'islands'; the goal is to connect two opposite islands of one's color. One way to prove that there must be a winner in a game of Atoll, Begird – and in fact infinitely many generalizations – uses a new generalization of Sperner's Lemma. (Received July 16, 2010)

1067-P1-299 **Anthony DeLegge*** (adelegge@ben.edu), 5700 College Road, Lisle, IL 60532. *Big Bucks, No Whammies: An Investigation of "Press Your Luck".* Preliminary report.

"Press Your Luck" was a popular TV game show that aired from 1983-1986. Contestants competed against each other and the show's famous "Big Board" to win thousands of dollars in cash and prizes, all while trying to avoid the dreaded Whammies, which bankrupted the players.

In this talk, we will discuss some of the interesting statistical exercises concerning this game, including how to determine the probability of hitting a Whammy and how to increase one's chances of winning money on any given spin. These exercises are designed to be accessible for students in a beginning statistics course. (Received August 17, 2010)

1067-P1-322 **W D Wallis*** (wdwallis@siu.edu), Department of Mathematics, Southern Illinois University - Carbondale, Carbondale, IL 62901-4408. *The 36Cube Puzzle.*

The 36Cube puzzle (made by Thinkfun) is based on 6×6 Latin squares, and its solution seems to require the existence of an orthogonal pair of such squares; of course, no such pair exists. We shall point out the actual configuration required, and briefly indicate that there is a statistical application of its existence. (Received August 22, 2010)

1067-P1-474 **Thomas Q. Sibley*** (tsibley@csbsju.edu), Mathematics Department, St. John's University, Collegeville, MN 56321-3000. *Puzzling Groups.*

We explore a family of puzzles, from easier ones that familiarize students with groups to more challenging ones. These puzzles involve interconnected wheels that permute pieces. Abstract algebra students enjoy working on the easier puzzles, which lead naturally to the more complicated ones. (Received September 06, 2010)

1067-P1-642 **Thomas J Dinitz*** (tdinitz@students.colgate.edu), 152 Forest's Edge, Hinesburg, VT 05461, and **Matthew Hartman** and **Jenya Soprunova** (soprunova@math.kent.edu). *Tropical determinants and cheating when solving the Rubik's cube.*

Consider the usual Rubik's cube with 9 square stickers on a side, and each sticker colored in one of six colors. Instead of solving it in the normal way (by rotating faces), we want to solve it by peeling off and replacing the stickers. In this presentation we will address the natural question: What is the maximum number of stickers you would ever need to peel off and replace? We first show that this problem can be translated to the language of matrices. Let A be a $6{\times}6$ matrix whose (i, j)th entry is the number of squares of color i in face j of the cube. Note that the matrix A has all its row and column sums equal to 9. The number of stickers that we do not need to peel off and replace is equal to the tropical determinant of A. We would like to find a matrix A with the lowest possible tropical determinant as this would provide an example of a Rubik's cube which needs the most number of stickers replaced. Stated more formally, our initial problem reduces to finding a sharp lower bound on the tropical determinant of $6{\times}6$ integer matrices A with non-negative entries and row and column sums equal to 9. We solve this problem as well as the general problem of n-by-n matrices with row and column sums equal to m. (Received September 12, 2010)

1067-P1-770 **Klay T Kruczek*** (kruczekk@wou.edu), Mathematics Department, Western Oregon University, 345 N. Monmouth Avenue, Monmouth, OR 97361. *On the Use of Fractional Matchings to Find Pairing Strategy Draws in N^d Tic-Tac-Toe.*

We will discuss the standard two-player N^d Tic-Tac-Toe game. In particular, we will concern ourselves with Player 2's ability to force a Pairing Strategy Draw (PSD), where he is able to pair off a subset of the points so that each winning line is assigned its own pair of points. It is known that if $N < \frac{2}{\ln 2}d - 1$, there is no PSD. On the other hand, with a very short proof, we are able to show that if $N \geq 3d - (d \mod 2)$, then the second player can force a draw by employing a pairing strategy after he finds a fractional matching of the points to the lines. Using similar methods and a much longer proof, one can show that if $N \geq 3d - O(\sqrt{d})$, then a PSD exists. (Received September 14, 2010)

1067-P1-826 **Doug Chatham*** (d.chatham@moreheadstate.edu), Dept of Math., Computer Science and Physics, Morehead State University, 150 University Blvd, UPO 701, Morehead, KY 40351. *Chessboard problems peppered with pawns.* Preliminary report.

We consider what happens to classic chessboard problems like the "n queens problem" and the "queens domination problem" when we allow ourselves to place pawns in some of the squares. We present some results and many open problems. (Received September 15, 2010)

1067-P1-886 **Philip Cobb*** (phcobb@prodigy.net), 41-31 210 Street, Bayside, NY 11361. *The minimal number of entries of a solvable Ken Ken.*

What is the minimum number of given digits needed to guarantee that a Sudoku puzzle has a unique solution? This remains unsolved; it is known only that it is at most 17.

The same question may be asked of the related puzzle Ken Ken. Like Sudoku, Ken Ken consists of a *Latin Square*, usually 4×4 or 6×6, in which each digit appears once and only once in each row and column. It is divided into regions, not necessarily squares, but any connected shape. Each region is given a numerical result, either a sum, difference, product, or quotient, and the operation sign. We may then ask for the minimum number of given numbers needed to solve the puzzle. Can the minimum be lowered if some regions have no numerical result?

The partition of the Latin Square into regions for a minimal solution can be done in essentially one way if the regions are connected. Other types of minimal puzzles can be constructed if the connected hypothesis is weakened. Although published puzzles are generally no larger than six by six, a Ken Ken with minimal givens exists for any size square. (Received September 16, 2010)

1067-P1-1024 **Elizabeth W McMahon*** (mcmahone@lafayette.edu), Department of Mathematics, Lafayette College, Easton, PA 18042, and **Kyle Kalail**. *Using SET® to Visualize AG(4,3).*

The card game SETff is a model for the 4-dimensional affine geometry of order 3, $AG(4,3)$. We will show how to use sets to visualize the lines (and thus the full structure) of $AG(4,3)$ and use that knowledge to answer questions about the geometry. We will show that it is possible to have any number of sets from 0 to 14 in 12 cards, but no more. In addition, further questions for exploration will be presented. (Received September 17, 2010)

1067-P1-1644 **Mary J. Riegel*** (riegelmj@mso.umt.edu), 410 N Surrey, Missoula, MT 59808. *"Fire and Ice".*

"Fire and Ice" is a variation on the classic game of Tic-Tac-Toe. Unlike Tic-Tac-Toe however, it is impossible for the game to end in a draw. The game was designed by Jens-Peter Schliemann and is produced by Pin International. The game board exploits the symmetries of the finite projective plane $PG(2,2)$, also known as the Fano Plane. The board is divided into seven islands, each containing seven points, arranged in the shape of $PG(2,2)$. Players attempt to control the board by possessing three islands in a line. Rather than placing a piece in an open position, a player moves one of his pieces to an allowed position, and then replaces the piece with an opponent's.

In this talk, we will explore several key properties of the board, which among other things prevent a draw. We will also discuss variations on the game by considering different geometries that share (or do not share) these properties. We will explore implications of the play mechanism, including an interesting consequence when used on a standard 3×3 board. We will calculate the game value for "Fire and Ice" as well as the game value for other boards, including describing situations in which Fire wins playing first. Finally, we will discuss various strategies for play. (Received September 21, 2010)

1067-P1-1684 **Dominic Lanphier*** (dominic.lanphier@wku.edu), Department of Mathematics, 1906 College Heights Blvd 11078, Bowling Green, KY 42101, and **Laura Taalman**. *Heartless Poker.*

The probabilities, and hence the rankings, of the standard poker hands are well-known. But what happens to the rankings in a game where a deck is used without a suit (heartless poker, for example), or with an extra suit, or extra face cards? Does it ever happen that two or more hands will be equally likely? In this talk we examine these and other questions, and show how probability, some analysis, and even some number theory can be applied. (Received September 21, 2010)

1067-P1-1697 **Edwin O'Shea*** (edwin.oshea@ucc.ie), School of Mathematics, University College, Cork, Ireland. *Bachet's problem: as few weights to weigh them all.*

A problem that enjoys an enduring popularity asks: "what is the least number of pound weights that can be used on a scale pan to weigh any integral number of pounds from 1 to 40 inclusive, if the weights can be placed in either of the scale pans?" W.W. Rouse Ball attributes the first recording of this problem to Bachet in the early 17th century, calling it "Bachet's Weights Problem". However, Bachet's problem stretches all the way back to Fibonacci in 1202, making it a viable candidate for the first problem in the thoroughly modern & active area of partitions of integers.

Remarkably, given the age of Bachet's problem, an elegant and succinct solution to this problem when we replace 40 with any integer has only come to light in the last 15 years. We hope to expound on this generalization here armed only with our sharp wits and a willingness to induct. In doing so we'll discover some of the joys of partitions of integers, recurrence relations, generating functions and counting integer points in polyhedra. (Received September 21, 2010)

1067-P1-1701 **Jason Rosenhouse*** (rosenhjd@jmu.edu), 305 Roop Hall, Dept. of Mathematics and Statistics., James Madison University, Harrisonburg, VA 22807. *The Monty Hall Problem, Reconsidered.*

The Monty Hall problem, also known as the game show problem or the three-door problem, is a classic brainteaser in conditional probability. The correct solution is so counter-intuitive that many people steadfastly refuse to accept it. We shall discuss the classical version of the problem, as well as several variations. This will allow us to clarify the probabilistic issues involved in understanding problems of this sort. (Received September 21, 2010)

1067-P1-1717 **Aaron J Maurer*** (maurera@carleton.edu), **John M McCauley** (jmccaule@haverford.edu) and **Silviya D Valeva** (valev20s@mtholyoke.edu). *Cops and Robbers on Planar Graphs.*

In the game of *Cops and Robbers* on a graph $G = (V, E)$, k cops try to catch a robber. On the cop turn, each cop may move to a neighboring vertex or remain in place. On the robber's turn, he moves similarly. The cops win if there is some time at which a cop is at the same vertex as the robber. Otherwise, the robber wins. The minimum number of cops required to catch the robber is called the *cop number* of G, and is denoted $c(G)$. The game of Cops and Robbers has applications in robotics and in search and rescue operations.

A classic result of Aigner and Fromme shows that if G is planar then $c(G) \leq 3$. We characterize the following families of planar graphs as having $c(G) \leq 2$: series parallel graphs, outerplanar graphs, maximal 2-outerplanar graphs, and maximal planar graphs with maximum degree at most 5. We also show that every graph G with $|V| \leq 9$ has $c(G) \leq 2$. This bound is tight, since the Petersen graph (on 10 vertices) requires 3 cops. (Received September 21, 2010)

1067-P1-1784 **Sandy Ganzell**, **Alex Meadows*** (ammeadows@smcm.edu) and **John Ross**. *Twist Untangle and its Discontents.*

We introduce Untangle, a combinatorial game inspired by knot theory, in which players take turns performing Reidemeister moves on a projection of the unknot. Twist Untangle is a simpler class of games, but is complicated enough to elude the typical analysis. It has been the topic of two recent undergraduate research projects. We will discuss the current state of knowledge of Twist Untangle, some ongoing research, and some straightforward open questions. (Received September 21, 2010)

1067-P1-1892 **Christine von Renesse*** (cvonrenesse@wsc.ma.edu), Department of Mathematics, 577 Western Ave, Westfield, MA 01086, and **Volker Ecke** (vecke@wsc.ma.edu), Department of Mathematics, 577 Western Ave, Westfield, MA 01086. *Discovering the Art of Mathematics: Straight-Cut Origami.*

Together with our students in "Explorations of Mathematics," a course for Liberal Arts majors, we have been exploring the mathematics of games and puzzles for a number of years now. Among the most successful topics with students are the Rubik's Cube, Hex strategy games, Sudoku puzzles, and paper-folding puzzles. The audience will have an opportunity to explore the mathematics of a few sample activities inspired by Eric Demaine's work on straight-cut origami from our inquiry-based learning guide *"Discovering the Art of Mathematics: Games and Puzzles,"* so come ready to play!

We find a number of strengths with this material: triggers for mathematics anxiety are avoided; success with the Rubik's Cube changes students' self-image; natural curiosity and competitiveness fuel the inquiry into game strategies (e.g. Hex); sophisticated, multi-step logical arguments arise organically (e.g. Sudoku); working with physical objects provides concrete models that supports thinking, reasoning, and communicating mathematics; symbols and notation arise as convenient means to clearly communicate mathematical thinking; "pressing the math" occurs through a focus on students reflecting on and explaining their reasoning. (Received September 22, 2010)

1067-P1-2011 **Anthony Tongen*** (tongenal@jmu.edu), MSC 1911, Department of Mathematics and Statistics, Harrisonburg, VA 22807, and **Laura Taalman** and **Roger J Thelwell**. *Solitaire Mancala.* Preliminary report.

Mancala is a popular "sowing" family of board games that originated in Africa and Asia. Sowing occurs when a player picks up stones in a particular bin and distributes them in adjacent bins. In order to better understand the movement of the stones in the more common two-player sowing games, we will focus on solitaire sowing games. We will examine Tchoukaillon, Tchuka Ruma, and newly created combinations of these games. We will analyze interesting patterns, uncover multiple ways to find a winning board, and examine how two different sets of moves can end in the same board state. (Received September 22, 2010)

1067-P1-2306 **Dennis P. Walsh*** (dwalsh@mtsu.edu), Box X070, Middle Tennessee State University, 1301 East Main Street, Murfreesboro, TN 37132. *Tic-Tac-Toe with Eeny, Meeny, Miny, Moe.*

By allowing various forms of randomness into the game of tic-tac-toe, one can escape the ubiquitous ties that occur when two smart people play the game. Using a simlpe random device, such as a coin or a die, a person can play tic-tac-toe against a phantom random player. We explore versions of the game that include random play versus random play, random play versus smart play, and random play versus random play. We will derive the win, lose, and tie probabilities for several variations showing, for example, that the probability of player

X winning a random-play-versus-random-play game (under uniform randomness) is approximately .585. These various random games lend themselves nicely to explorations by students, and instructors can use the games to introduce or reinforce basic counting principles. (Received September 22, 2010)

1067-P1-2333 **Catherine Stenson*** (stenson@juniata.edu), Juniata College, 1700 Moore St., Huntingdon, PA 16652. *Turn the Tide: A Game for Undergraduate Research Projects.*

Turn the Tide is a charming card game that could form the basis of several undergraduate research projects. Each player has a "tide card" showing. In each round, players bid for two new tide cards. The highest bidder gets the lower tide card and the second-highest bidder gets the higher tide card. The other bidders keep their original tide cards. At the end of the round, the player with the highest tide card loses a life preserver. We present the rules of the game, describe some preliminary results, and pose some problems suitable for undergraduates. (Received September 22, 2010)

1067-P1-2340 **Robin Leigh Blankenship*** (r.blankenshi@moreheadstate.edu), **Michael Blankenship** and **Craig Hamilton**. *Counting the Number of Hextile Knot Mosaics in a Diagram with Fixed Center and Radius.* Preliminary report.

Knot mosaics, embeddings of knot diagrams in square grids, inspired the creation of hextiles: regular hexagons with zero, one, two, or three strands connecting midpoints of edges in various over and under crossing patterns. After creating hextiles out of ceramics and introducing the puzzle of tessellating hextiles to form knots and links, natural mathematical questions arose. One such question is, "How many hextile knot mosaics are there?" This has been determined for a given radius around a fixed center tile using a computer program written in C#. (Received September 22, 2010)

1067-P1-2376 **Matthew P Conlen*** (mpconlen@umich.edu) and **Juraj Milcak**. *A Winning Strategy for Tic-Tac-Toe on an Affine Plane of Order 4.*

Our research looks at the classic game Tic-Tac-Toe as played on finite geometries, in particular the affine plane of order 4. J. Yazinski and A. Insogna have given a computational proof that this game may always be won by the first player. We provide a simple winning strategy and proof of its correctness. To do so, we use mutually orthogonal latin squares to coordinatize points and place lines into parallel classes. Consider any subgraph of the game board such that the subgraph is itself an affine plane of order two. We denote the set of points of any such subgraph as S. We prove that the first player is always able to create a set S, and then show that this set can be extended to produce a winning line. (Received September 22, 2010)

The Mathematics of Sustainability

1067-Q1-156 **Stephen G Hartke*** (hartke@math.unl.edu), Dept of Mathematics, Univ of Nebraska-Lincoln, Lincoln, NE 68588-0130, and **Petronela Radu**, Dept of Mathematics, Univ of Nebraska-Lincoln. *Math in the City: A hands-on learning experience with projects on sustainability.* Preliminary report.

Math in the City is an interdisciplinary course in which students engage in a hands-on learning experience using mathematical modeling to understand current major societal issues of local and national interest. The course is run in collaboration with local businesses and research centers with students creating and analyzing models based on real data. Some recent projects include the design and construction of green buildings and on how to optimize the city's recycling program. In this talk I will focus on these sustainability projects and talk about potential future projects. The course will be further developed while supported by a STEM (former CCLI) NSF award and it will be disseminated to other colleges and universities. (Received July 28, 2010)

1067-Q1-579 **Amy Kelley*** (amy.kelley@gcsu.edu), Georgia College & State University, 231 W. Hancock St., CBX017, Milledgeville, GA 31061, and **Julia Metzker** (julia.metzker@gcsu.edu), Georgia College & State University, 231 W. Hancock St., Milledgeville, GA 31061. *Teaching Non-Science Majors Basic Modeling -A Cluster of Courses Focused on Climate Change.* Preliminary report.

At Georgia College & State University a two-course cluster composed of a basic modeling course at the level of college algebra and an interdisciplinary science course have been designed around the theme of climate change. First-year non-science majors needing to fulfill their general education requirements enrolled in both courses complete several joint projects, which combine the mathematical and scientific concepts necessary for understanding the scientific and social impacts of climate change. In this talk we present how the use of a common theme was integrated into the course design process, desired learning outcomes, tandem class activities, and assessment instruments for the course. We also present some preliminary results from attitudinal surveys and lessons learned. (Received September 10, 2010)

1067-Q1-1740 **Andrew E Long*** (longa@nku.edu), 495 Rossford Ave, Ft. Thomas, KY 41075. *Global Warming-Based Calculus.* Preliminary report.

I'm trying an experiment in calculus: rather than teach the **tools** of calculus, I've decided to focus on the **ideas** of calculus, and trust that the tools (skills) of calculus will follow. Keith Devlin recently asserted that "Mathematics is a way of thinking about problems and issues in the world. Get the thinking right and the skills come largely for free." I decided to take Devlin at his word, and present the right thinking of calculus through the data and ideas of global climate change.

Each class my students work in groups on a lab which I've created, focusing on some specific issue of calculus (e.g. rates of change), but going at it from the standpoint of, say, the rate of change of global sea level. We're using real data, obtained from various primary sources such as NOAA's National Climatic Data Center.

In my talk I will 1) present more about my motivation to improve my calculus instruction in this way; 2) explain why I believe that the data of climate change is so important (and so appropriate) as source material for the ideas of calculus; 3) provide access to the data that I've used or created for classroom use; 4) show examples of the labs I've created; and 5) describe results from this first attempt at global warming-based calculus. (Received September 21, 2010)

1067-Q1-1878 **Lily S. Khadjavi*** (lkhadjavi@lmu.edu), Loyola Marymount University, 1 LMU Drive Suite 2700, Los Angeles, CA 90045, Los Angeles, 90045. *Climate change and the mathematics of sustainability in student projects for calculus and statistics courses.*

The mathematics of sustainability lends itself to bringing real-world questions into the classroom and presents us with an excellent opportunity for students to consider these questions for themselves. Students recognize topics from the news headlines, but rarely have they had the chance to directly analyze data related to these situations.

The goal of this session is to provide concrete resources – including sources of data and background material – so that projects accessible to calculus and statistics students can be easily incorporated into such courses.

Moreover, these projects fit well with growing interest in multidisciplinary work and student writing. In order to effectively use their mathematical tools and tackle problems of sustainability, students must be able to communicate clearly to those outside of their classroom. The talk will focus on specific examples related to climate change and to the BP oil spill. Sample writing assignments will be described, along with background information that students can be given as motivation for their analysis, e.g., international agreements limiting average temperature increase and carbon emissions, or BP's claims about the size of the spill. (Received September 23, 2010)

1067-Q1-2140 **Jeremy Case*** (jrcase@taylor.edu), Taylor University, 236 W. Reade Ave, Upland, IN 46989. *Do sustainability problems in mathematics really affect student attitudes?* Preliminary report.

Mathematical models in sustainability provide provocative mathematical examples although there often seems to be a question of realism. In Calculus 2, we use several examples involving sustainability including estimates of greenhouse gases in the atmosphere, the sustainability of commercial shrimp farming, and the use of genetically modified salmon to ease world hunger. While the primary purpose is to motivate the mathematical ideas, a lab book given to students provides detailed scientific references, sources, and background information regarding the environmental situations. What effect does this approach have on students learning mathematics or on their attitudes towards the environment? In addition to exploring the mathematical examples, we will report on student feedback given at the end of the course and in subsequent semesters. (Received September 22, 2010)

1067-Q1-2344 **David Kung*** (dtkung@smcm.edu), 18952 E. Fisher Rd, St. Mary's College of Maryland, St. Mary's City, MD 20686. *Math and Social Justice: Improving the world with semester projects in a liberal arts math course.*

College students' last math class could rehash algebra, teach "useful mathematics" that will never be used, wax philosophical about esoteric mathematics - or we could use this opportunity to teach students how to use mathematics to improve the world.

In this liberal arts math course aimed at non-science majors, every student proposes a project that will use math to tackle an issue of their choosing - and most choose a sustainability-related topic. Through the course of the semester, groups of students tackle renewable energy projects, conservation initiatives, and fair trade issues.

By the end, they have learned both interesting mathematical content and how to apply it to be an informed, responsible, and active citizen.

This talk will describe the course, give examples of student projects, and present data on changes in students' quantitative literacy skills and attitudes toward mathematics. (Received September 22, 2010)

Modeling in the ODE Driver's Seat

1067-R1-118 **Rachael Miller Neilan*** (rmill48@lsu.edu), 2139 Energy, Coast, and Environment Building, Louisiana State University, Baton Rouge, LA 70803. *Calibrating, Simulating, and Evaluating an Exposure-Effects Model for Fish Growth.*

Ordinary differential equations are often used to describe the dynamics of fish growth. During exposure to a stressor such as hypoxia (low dissolved oxygen, DO), instantaneous growth rates of fish decline. When conditions improve, growth rates return to normal. We show how published data from experiments in constant hypoxia can be used to calibrate an exposure-effects model for fish growth. During fluctuating conditions, DO can be approximated and model equations can be solved on an hourly-time step to compute the growth of a fish. We will discuss how students can calibrate, implement, and evaluate the exposure-effects model. (Received September 21, 2010)

1067-R1-237 **Chris Arney*** (david.arney@usma.edu), Dept of Math, USMA, West Point, NY 10996. *Mathematical Modeling of "hearts and minds" in the Terrorism/Counter-Terrorism Struggle.*

Students in differential equations courses should see and experience the complexity of real applications and their utility in society. An interesting and accessible, real and relevant, military-political application with many complex interactions is the struggle between terrorism (T) and counter-terrorism (CT). We model the T-CT struggle with a large system of first-order differential equations that includes factors such as leadership, promotion, recruitment, resources, operational techniques, cooperation, intelligence, science, and psychology taken from policies and procedures found in terrorism and counter-terrorism manuals. We share our experience of teaching this large systems of differential equations using this modeling-first approach. We see from our analysis that it is easy to confirm what we see in the news – in insurgencies, asymmetric warfare (terrorism) wreaks havoc upon the less flexible force. For military forces to be effective against terrorism, the mathematics shows they must possess flexibility. The presentation provides a student view of confronting complexity in modeling and solving and analyzing large systems. (Received August 11, 2010)

1067-R1-380 **Michael Huber*** (huber@muhlenberg.edu), Department of Mathematics & Computer Science, Muhlenberg College, Allentown, PA 18104. *Modeling Malaria in Central America.* Preliminary report.

Malaria is endemic to more than 100 countries and territories worldwide and although the disease is predominantly found in the tropic and subtropic regions (more than 90% of malaria cases occur on the African continent), there is a significant risk associated with parts of the Pacific, Latin America, and Asia. This presentation will outline a course project which involved three approaches to studying the effects of malaria in Central America. First, we considered the pharmacokinetics of the chemoprophylaxis, an exponential decay problem. Next, we studied a compartmental model (known as SIRS), as susceptible individuals are repeatedly infected, recover, enjoy temporary immunity, and again become susceptible. Finally, we considered the nonlinear coupled equations for humans and mosquitoes, which assume that the transmission of plasmodium, both from mosquito to man and from man to mosquito, will depend jointly on the number of susceptible and infected population of each species. This project, used in an introductory ODEs course, encouraged students to develop appropriate models and solve them using various techniques, with the aid of a CAS. (Received August 30, 2010)

1067-R1-1504 **Kimberly R. Swetz*** (kimberly.swetz@usafa.edu), Dept of the Air Force, HQ USAFA/DFMS, 2354 Fairchild Dr, Suite 6D124, USAF Academy, CO 80840-6252. *An Ode to Modeling with ODEs.*

One of the goals of the ODE course at the US Air Force Academy is to allow students to practice their modeling skills by exposing them to a variety of scenarios. We believe that modeling exercises are useful because they allow students to practice analytic, qualitative, and numeric skills all within the same context. Some of the topics that I've used in recent projects include: a droplet of water, electric circuits, the swine flu, the oil spill in the Gulf, and the Tacoma Narrows Bridge. In this talk, I will share a few of these modeling exercises and also briefly discuss the pedagogy that I've used to assess the modeling efforts of the students. (Received September 21, 2010)

1067-R1-1542 **Elizabeth Thoren*** (ethoren@math.ucsb.edu), Department of Mathematics, South Hall Rm 6607, University of California, Santa Barbara, CA 93106. *A Week in the Life of an Inquiry-Based ODEs Course.* Preliminary report.

This fall I had the pleasure of teaching UC Santa Barbara's Inquiry Based ODEs course. The entire course is project driven - each week students work through an investigation, write up a project report and present their results. For this talk I will share the Fall quarter's most interesting modeling project, including the students' reactions and results. (Received September 21, 2010)

1067-R1-1680 **Jennifer Ann Czocher*** (jczocher@math.ohio-state.edu). *Comparing an Applications-first Approach and an Analytic Techniques-first Approach to Teaching Topics in Differential Equations.* Preliminary report.

The subject of this talk will be an analysis of student solution strategies in an introductory course on differential equations for engineering majors. The analysis arises from a study designed to examine and compare the efficacy of two curricula, as implemented in two different lectures and is informed by the literature on conceptual knowledge. Preliminary results suggest that students do respond to differing instruction in concrete and detectable ways. (Received September 21, 2010)

1067-R1-1796 **Yajun Yang*** (yangy@farmingdale.edu), Department of Mathematics, Farmingdale State College of SUNY, 2350 Broadhollow Rd, Farmingdale, NY 11735. *Making Differential Equations More Relevant to Electrical Engineering Technology Students.*

The Department of Mathematics at Farmingdale State College offers a mathematics sequence for the students in Electrical Engineering Technology (EET) programs. The last course in the sequence is Advanced Mathematical Analysis. The topics of the course range from Infinite Series, Taylor Series, Fourier series, to First and Second Order Differential Equations and Applications, Laplace Transform. To make the course content relevant to my students, I use electrical circuits such as RL and RLC circuits to introduce topics of elementary ODE. I encourage the students to bring in electrical engineering problems from their EET classes. As a result, we analyze electrical systems to derive systems of differential equations, which is not part of the syllabus. I will present a sample of the student projects of real-world electrical engineering problems. (Received September 21, 2010)

1067-R1-1973 **Lester F Caudill*** (lcaudill@richmond.edu), Dept of Mathematics and Computer Science, 28 Westhampton Way, Univ. of Richmond, VA 23173. *ODE Models in Medicine.*

We present two examples of final projects used in the course "Mathematical Models in Biology and Medicine" at the University of Richmond. The first involves modeling the growth of a cancerous tumor and the effects of radiation therapy. The second involves the interaction of two strains of bacteria - differing in their susceptibility to a particular antibiotic, and the subsequent impact of varying levels of use of that antibiotic. (Received September 22, 2010)

1067-R1-2323 **Janine M Haugh*** (jhaugh@unca.edu), 1 University Heights, CPO #2350, Asheville, NC 28804. *Cartilage Regeneration in Cell-Seeded Scaffolds: An ODE Modeling Approach.* Preliminary report.

Articular cartilage is the hydrated orthopaedic soft tissue that lines the surfaces of bones in diarthrodial joints (i.e. knee, shoulder, hip). Cartilage degeneration due to osteoarthritis or injury can lead to osteochondral defects in the cartilage, and cartilage have a limited capacity for self-repair. In recent years, the use of nutrient-rich hydrogels and scaffolds seeded with chondrocytes as potential biomaterials for tissue regeneration and repair has seen wide interest, but the optimal combination of diverse factors required to successfully regenerate articular cartilage is not known.

Obtaining spatial data is difficult, and cartilage regeneration occurs on time scales that span many weeks to several months. As a result, many experimentalists have measured only scalar system variables such as scaffold or collagen dry mass at a small number of time points. An ODE modeling approach appears to be a natural choice for analysis of dynamic evolution of these system variables. These ODE models can be calibrated using experimental data by way of a nonlinear least squares approach, and a parametric analysis can be performed to quantify the effects of model parameters on a regeneration time for a targeted value of linked ECM. (Received September 22, 2010)

New and Continuing Connections between Math and the Arts

1067-S1-219 **Reza Sarhangi*** (rsarhangi@towson.edu), Reza Sarhangi, PhD, Department of Mathematics, Towson University, 8000 York Road, Towson, MD 21252. *A Workshop in Geometric Constructions of Mosaic Designs.*

The focus of this presentation is to study two different approaches for creating mosaic designs and to compare them. A traditional and well-known method in this regard is using a compass and straightedge. The other method that will be introduced and discussed during this talk is the use of the modularity method. Modularity is a special cutting and pasting process of tiles to create tile designs. During this talk the participants will learn how to create a series of designs using a compass and straightedge, and then how through some hands-on activities they may discover the same designs using modularity. The cuts in the modularity method are elementary in that they cut the tiles (mainly squares) along line segments, such as the diagonals, to divide the tile into two or three pieces. For certain designs, there are more detailed methods of cutting that the participants should execute to construct more complex geometric shapes. (Received August 07, 2010)

1067-S1-233 **Deane E Arganbright*** (dearganbright@yahoo.com), Dept of Maths and CS, Divine Word University, PO Box 483, Madang, Papua New Guinea, and **Susan C Arganbright** (scargan1@yahoo.com), Divine Word University, PO Box 483, Madang, Papua New Guinea. *Mathematics, Excel, and Graphic Design in Multicultural Alphabet Books for Papua New Guinea.*

Papua New Guinea is a nation of 6 million people, widely diverse cultures, hundreds of traditional counting systems, and over 800 distinct languages. This presentation describes a multidisciplinary project that combines cultural aspects with such academic areas as art, language, mathematics, and computing science to produce creative alphabet books in the country's three official languages (English, Melanesian Pidgin, Hiri Motu). The innovative visual images in the books consist of modern and traditional objects created employing standard features of Microsoft Excel. The designs incorporate a variety of classical mathematical curves and geometric constructions. Together with the development of a related Web site, the work is designed to be extended to the nation's other languages to help in preserving cultures, to promote renewed interest in children's reading, and as a tool to encourage innovative applications of mathematics and computing in schools and universities. The approach employed is fully adaptable to the languages of other nations. This presentation will not only display examples of the books' full-color graphic designs and artwork, but also will illustrate how mathematics can be used with a spreadsheet to produce eye-catching animated versions of the images. (Received August 11, 2010)

1067-S1-247 **Frode Ronning*** (frode.ronning@hist.no), Sor-Trondelag University College, Fac. of Teacher Education, 7004 Trondheim, Norway. *Islamic decorations and wallpaper groups.*

Islamic buildings are very often richly decorated with patterns covering large surfaces, and it is mathematically interesting to classify these patterns in terms of their symmetries, i.e. connecting each pattern to one of the 17 wallpaper groups. On many occasions the question has been raised whether one in decorations from Islamic art will find representatives of all the 17 different wallpaper groups, and contradicting answers to this question have been given. In particular this question has been thoroughly investigated, and with contradicting conclusions, in connection with the Moorish palace Alhambra in Spain. In this talk I will discuss how it can be possible to come to different conclusions about the existence of all 17 wallpaper patterns, in particular within a restricted area like the Alhambra palace. I will address some problems that come up when trying to determine which wallpaper group a given pattern belongs to. This will connect to fundamental ideas about the nature of mathematical concepts and the relation between a mathematical concept, its representations and the reference contexts in which it appears. The talk will be richly illustrated with pictures, in particular from the Alhambra. (Received August 12, 2010)

1067-S1-344 **Harrison W. Straley*** (straley_harrison@wheatonma.edu), 500 Elm St., Mansfield, MA 02048. *Student-Written Plays in a History of Mathematics Class.*

Mathematics does not stand alone; it lives in the historical context. Students seldom recall a paper they wrote years ago in a college class. However, it is reasonable to expect that students will recall a play they researched, wrote, produced, and presented to both an on- and an off-campus audience.

Eighteen students in the History of Mathematics course at Wheaton College, Norton, MA were partitioned into groups of three students. Each group researched, wrote, produced and presented an original play on a history of mathematics topic. The plays were presented on-campus to an audience representing the general student body and off-campus at either a meeting of the North Eastern Section of the MAA or at a local middle school. This paper outlines the procedures used to help the students select and research their topics and to support their efforts at writing, producing, and presenting a historical play about mathematics or mathematicians. The paper concludes with student reactions to this unique experience. (Received August 25, 2010)

1067-S1-384 **Susan McBurney*** (smcburne@iit.edu), 211 Rugeley Road, Western Springs, IL 60558. *Decoding DaVinci.*

Leonardo DaVinci was a master of many disciplines, whose curiosity and creativity seemed to know no bounds. Later in life he developed an interest in geometry that never left him. However, his geometric notebook drawings have been dismissed by some as "a mere intellectual pastime". Others suggest a deeper understanding. This presentation seeks to evaluate two particular pages of his folio which contain more than 170 sketches. Some categorization and analysis of these diagrams will be explored according to a variety of criteria. (Received August 30, 2010)

1067-S1-508 **Anne Burns*** (aburns@liu.edu), Department of Mathematics, Long Island University, C.W. Post Campus, 720 Northern Blvd., Brookville, NY 11548. *Flash-y Pictures: Go with the Flow.* Preliminary report.

Complex-valued functions can be interpreted as vector fields. If the value of a complex function is interpreted as a vector in the complex plane, there are various ways of coloring a portion of the plane. Color can be assigned to each pixel in a two dimensional region of the plane or we can picture a vector emanating from each point in the region. There are many ways to make the color assignments, limited only by the imagination of the artist. One example is coloring the pixel according to the arctangent of the angle made by the (complex) value of the function with the x-axis. Another example is coloring the pixel according to the magnitude of the value of the function. Images and animations created with Flash will illustrate these and other interpretations of complex-valued functions. (Received September 07, 2010)

1067-S1-791 **Caleb Emmons*** (emmons@pacificu.edu), Dept. of Mathematics and Computer Science, 2043 College Way, Forest Grove, OR 97116. *How to cook up a math poem in n easy steps.* Preliminary report.

Mathematical poetry attempts to distill a mathematical concept and present it in a literary or visually interesting way. For example, is the text "−− . . −   . . −. .   .. −−−   −− −.−− .−. − .−.. .   − .. . −..   ..− .−−. − .. . − − . ...   −.. . − −. − ." the beginning of π in binary (with $1 \leftrightarrow -$ and $0 \leftrightarrow .$), or the beginning of a poem written in Morse code? Both! In this talk I outline my general method for writing mathematical poetry and elucidate it with several examples, including an extended meditation on the composition of the poem referenced above. (Received September 14, 2010)

1067-S1-888 **Phil Gustafson*** (pgustafs@mesastate.edu), Department of Mathematics, Mesa State College, Grand Junction, CO 81501. *What Does That Picture Sound Like? Calculus and Photosounder.*

Photosounder is a software application that converts a digital image into a sound file. It accomplishes this by associating the color intensity levels in the image with a frequency distribution, or frequency spectrum, which can then be played back as a corresponding sound wave. We will see how calculus plays a role in this process while hearing how a variety of images sound, including the Mona Lisa, string art, and computer generated images. (Received September 16, 2010)

1067-S1-1004 **Anneke Bart*** (barta@slu.edu), 220 N. Grand Blvd, St. Louis, MO 63103. *Math and the art of M.C. Escher.*

We have taught Math and the art of M.C. Escher as a freshman geometry course since 2001. We have written an online text which is available for free at http://mathcs.slu.edu/escher.

Topics include Euclidean, spherical and hyperbolic geometry, and a choice of other topics such as fractals, the fourth dimension, etc. The course is taught using a lot of group explorations. Grading in this course is done using a combination of projects and conventional type exams. The talk will include a short overview of the course and topics covered. (Received September 17, 2010)

1067-S1-1164 **Vi Hart*** (vi@vihart.com). *Hyperbolic Planes Take Off!*

This year I developed a sudden interest in making representations of the hyperbolic plane in many mediums: balloons, beadwork, drawing, plastic, sewing, and others. Some of these attempts created mathematical problems, for example how to decompose the graph of a hyperbolic tiling into optimal pieces for making it modularly out of balloons. Having physical models of the hyperbolic plane helped me to develop my intuition of the many ways the hyperbolic plane can look when embedded in three dimensions, such as how it can fold into Schwartz' P surface. Drawing and painting, especially, require this intuition, and allow the freedom to imagine the hyperbolic plane in ways it has never been seen before. These new visions led to more mathematical insights: for example, the every-day transformation of "shriveling up" can turn a Euclidean plane into a hyperbolic one, as seen in dried apple slices. This journey through representations of the hyperbolic plane highlights the ways that mathematics and art communicate with each other, leading to both beautiful art and beautiful math. (Received September 19, 2010)

1067-S1-1520 **Rachel B Manspeaker*** (rbm001@math.ksu.edu), 126 Cardwell Hall, Manhattan, KS 66502, and **Andrew Bennett**, **Hien Nguyen** and **Peter Nguyen**. *Using Art to Inspire Conceptual Understanding of Fractions.*

Fractions and units are difficult concepts for many students. The literature indicates that many teachers rely on only one or two models of the notion of a fraction (typically pie slices) and this may limit their pedagogical success. During a two-week workshop for middle-level mathematics teachers, we worked on strengthening the teachers' understanding of mathematical concepts and their abilities to explain those concepts to students of varied backgrounds and interests by making connections between mathematics and art. In this talk we will discuss several unusual and illuminating models of fractions in the context of art and music that were developed with teachers during the workshop. (Received September 21, 2010)

1067-S1-1691 **Vladimir L Bulatov*** (vladimir@bulatov.org), 2970 Christine Street, Corvallis, OR 97330. *Tilings of hyperbolic space and their visualization.* Preliminary report.

Visual representation of tiling of 3D hyperbolic space attracted very little attention compare to tilings of hyperbolic plane, which were popularized by M.C.Escher circle limit woodcuts. Although there is a lot of activity on theoretical side of the problem starting from work of H.Poincare on Kleinian groups and continuing with breakthrough of W.Thurston in the development of low dimensional topology and G.Perelman's proof of Poincare conjecture.

The book "Indra's Pearl" have popularized visualization of 2D limit set of Kleinian groups, which is located at the infinity of hyperbolic space. In this talk we present our attempts to build and visualize actual 3D tilings. We study tilings with symmetry group generated by reflections in the faces of Coxeter polyhedron, which also is the fundamental polyhedron of the group. Tiling based on Coxeter polyhedra with up to 8 faces are constructed. The text of the talk is available at http://bulatov.org/math/1101/ (Received September 21, 2010)

1067-S1-1692 **Robert W. Fathauer*** (tessellations@cox.net), 3913 E. Bronco Tr., Phoenix, AZ 85044. *Photographic Fractal Trees.*

A wide variety of fractal trees have been created using photographic imagery. Raw photographs are manipulated and sometimes combined to create building blocks. Each building block branches from a single large trunk to two or more smaller branches. These building blocks are used to construct trees via an iterative process. With each iteration, the trunks of multiple smaller copies of the building block, that have been rotated and sometimes reflected, are arranged adjacent to the smaller branches of a larger building block. The building blocks are designed in such a manner that the joints between different sized blocks are seamless. A set of assembly rules is consistently followed from one iteration to the next, with anywhere from 6 to 40 iterations used to create a fractal tree. Trees have been constructed using this technique that are in some cases relatively realistic, and in other quite fantastical. Randomness in the construction process has also been explored, with the use of dice to generate random numbers dictating the construction rules for each iteration. Randomness can lead to the creation of significantly more natural looking trees. (Received September 21, 2010)

1067-S1-1827 **Kurt E Ludwick*** (keludwick@salisbury.edu), Department of Mathematics & Computer Science, 1101 Camden Ave, Salisbury, MD 21801. *Teaching Mathematics Through Music for a Liberal Arts Audience.* Preliminary report.

A "Mathematics for the Liberal Arts" course is an opportunity to invite the scientifically disinclined college student to experience the beauty, depth, and relevance of mathematics. Within the context of music, we can explore a wide range of mathematical concepts.

Based on my experiences teaching multiple offerings of a "Music and Mathematics" course designed for non-science majors, I will discuss some fruitful strategies and activities for exploring topics such as exponents and logarithms, combinatorics, modular arithmetic, introductory group theory, and symmetric groups. (Received September 21, 2010)

1067-S1-2216 **Craig M. Johnson*** (craigj374@gmail.com), Marywood University, 2300 Adams Ave., Scranton, PA 18411. *Inversions and the Dihedral Group in Music.* Preliminary report.

An inversion is defined here as the function giving the new key of a piece of music resulting from inverting every note across a specific pivot note. The set of 6 distinct inversions form a coset of a particular subgroup of the dihedral group D12 of order 24. We explore the structural and aesthetic effects of performing inversions on different genres of music compositions. Why does the human ear perceive some musical segments as beautiful and others as dissonant? A different partition of D12 may provide the answer. (Received September 22, 2010)

1067-S1-2228 **George W. Hart*** (hart@momath.org), Museum of Mathematics, 134 West 29th Street, Suite 709, New York, NY 10001. *Art at the Museum of Mathematics.*

The Museum of Mathematics (momath.org) will open in Manhattan in 2012 with a mission to communicate the richness of mathematics through innovative exhibits and programming. Visitors to the museum will explore mathematical ideas in a fun, hands-on manner. We have already designed and built interactive exhibits for our traveling exhibition, the Math Midway (mathmidway.org), which is currently touring science museums around the country. An iconic part of that exhibition is the square-wheeled tricycle, which visitors ride smoothly around a circular track of catenary arcs. Such whole-body experiences provide one way to appreciate math; art provides another. The Museum of Mathematics will include a dedicated art gallery to show several exhibitions annually, allowing visitors to engage in visual modes of thinking which connect math and art. The recent surge in mathematical art, including the formation of SIGMAA-ARTS, the annual JMM art exhibition, and the growth of interdisciplinary conferences such as Bridges and ISAMA, convinces us that a significant body of mature artwork is available. The Museum of Mathematics will bring it to new audiences. We will collaborate with the math/art community for curatorial ideas and support, including ideas for art-related hands-on activities. (Received September 22, 2010)

1067-S1-2302 **Mary L Garner*** (mgarner@kennesaw.edu), 4621 Ivygate Circle, Smyrna, GA 30080.
Sequences, Series, Combinatorics, and Probability in the Early Plate Work of Jennifer Bartlett.

Jennifer Bartlett is an American artist whose work has been featured in museums and art galleries internationally, including the Museum of Modern Art, the Metropolitan Museum of Art, and the Hirshhorn Museum, to name a few. Her medium for her early art work was one-foot square steel plates coated with white enamel and imprinted with a graph-paper grid. In interviews, she has stated that she would have an idea about a certain "numerical system" and then seek to visualize that system. Bartlett's plate work provides a perfect intersection for art and the mathematics of sequences and series and could be used in mathematics classrooms at a variety of levels. (Received September 22, 2010)

1067-S1-2347 **Darrah P. Chavey*** (chavey@beloit.edu), Beloit College, 700 College St., Beloit, WI 53511. *Glide Reflections as a Cultural and Artistic Value.* Preliminary report.

In linear designs, some cultures, and certain art forms, regularly use glide-reflections as a pattern symmetry within their art. Other cultures and art forms avoid the use of such symmetries. Of course glide-reflections are probably the most difficult linear symmetry to see, and so some avoidance may be due to this difficulty. Some uses and avoidances may be due simply to a tradition that limits what patterns are "acceptable". We will argue, though, that in at least some cases the preference for or against glide-reflections are due to specific artistic goals, cultural phenomena, or historical reasons. (Received September 22, 2010)

Philosophy of Mathematics in Teaching and Learning

1067-T1-159 **James R. Henderson*** (henderso@pitt.edu), 504 E. Main Street, Titusville, PA 16354.
Causation and Explanation in Mathematics.

One of the trickier issues in teaching a statistics course is making clear the causation/correlation distinction. Consider: (1) There is 100% correlation between mammals and animals having three bones in the middle ear. This all-and-only parallel seems to be a completely accidental evolutionary happenstance. (2) There is a very strong positive correlation between the shoe size and reading-comprehension scores of children. Here shoe size and reading scores are the twin effects of the common cause of aging. (3) Any free hydrogen atom is capable of bonding with any free fluoride atom. This stems directly from the atomic structures of hydrogen and fluoride. The subject of causality may seem far removed from the objects of mathematics, but Bernard Bolzano formulated a theory of cause and effect for (among other things) mathematical propositions in his 1837 Theory of Science.

I will consider what Bolzano has to say about causality in mathematics and see what implications there are for the related subject of mathematical explanations. (Received July 28, 2010)

1067-T1-712 **Jeff Buechner*** (buechner@rci.rutgers.edu), Dept of Philosophy Conklin Hall 432, 175 University Avenue, Rutgers University, Newark, NJ 07102. *Mathematical Understanding and Philosophies of Mathematics.* Preliminary report.

I will argue that there are theorems in mathematics whose understanding (both in a psychological and a philosophical sense) depends upon holding a certain philosophy of mathematics. Are there any theorems common to all philosophies of mathematics which can be understood within any mathematical philosophy? Yes: there are theorems of elementary number theory that we understand only when we have a de re attitude toward natural numbers, regardless of which mathematical philosophy one holds. However, if we have only a de dicto attitude toward the natural numbers, we might not understand those theorems. This suggests a pedagogical strategy for both teaching and learning mathematics and also creates a philosophical problem: how can we explain those areas of mathematical practice on which all mathematical philosophies agree and then show how in extensions of that practice different mathematical philosophies differ as to the content of the set of theorems of those extensions. Finally, are there any theorems common to all philosophies of mathematics which can only be understood within a particular mathematical philosophy? I provide an example of one theorem, which draws on the work of Harvey Friedmans program of Boolean Relation Theory. (Received September 14, 2010)

1067-T1-1395 **Martin E. Flashman*** (flashman@humboldt.edu), Department of Mathematics, Humboldt State University, Humboldt State University, Arcata, CA 95521. *Square Roots: Adding Philosophical Contexts and Issues to Enhance Understanding.* Preliminary report.

The nature of numbers can be confusing to students in a variety of learning contexts. One frequently encountered area of confusion surrounds numbers described as square roots, such as the square root of 2 and the square root of -1. The author will examine how illuminating some philosophical approaches to the nature of numbers (ontology) and knowledge about numbers and their properties (epistomology) can help students avoid some possible confusion. Time permitting the author may suggest possible empirical studies for (college level) students to provide evidence for the utility of introducing more philosophical approaches to pedagogy. (Received September 20, 2010)

1067-T1-1527 **ruggero ferro*** (ruggero.ferro@univr.it), via gabelli 57, 35121 padova, Italy. *Abstraction and objectivity in mathematics.*

I would like to read the theme of this conference the other way around: which problems in the philosophy of mathematics are raised from the teaching/learning perspective? For example. Why can we learn and understand mathematics? How do we learn mathematics? We cannot appeal to general philosophical principles and derive answers from them, because we would fall into a vicious circle: how do we know that a proposed philosophy is correct and can justify the deriving theory of knowledge? To avoid this, one has to investigate the ways of knowing and learning mathematics without any reference to a pre construed theory. But this process is internal to the human being. From outside we can only observe consequences and results of having acquired a notion. Even a description of what it is being done, is just a description in a language and should be interpreted. Being impossible to analyze the process from outside, why not trying to look at it from inside through introspection? The conclusions would be subjective! Why so? We are just talking about learning and understanding mathematics. I would like to show that, along this way, something could be said, for instance about abstraction, and the conclusions should be considered objective, according to a reasonable notion of objectivity. (Received September 21, 2010)

1067-T1-1766 **Thomas Drucker*** (druckert@uww.edu), Department of Math. and CS, University of Wisconsin–Whitewater, 800 West Main Street, Whitewater, WI 53190. *Putting Content into a Fictionalist Account of Mathematics for Non-Mathematicians.* Preliminary report.

Non-mathematicians will often take a course in mathematics and literature with a much greater degree of comfort with the literary side than with the mathematical side. This comes partly from their sense of mathematics as a collection of rules handed down to them in classrooms of years past. One way to try to bridge the gap is not just to look at the mathematical aspects of literary structure and the representation of mathematical ideas in literature. Instead, one can explain the notion of fictionalism as a positive characterization of mathematical objects. Old-style fictionalism took mathematics as simply a tissue of useful lies. A more constructive fictionalism takes seriously the resemblance to fiction, especially for those who have put some time into trying to understand statements in fiction and their truth values. The repudiation of literalism on both sides of the divide (mathematical and literary) leads to a rapprochement of understanding the statements in mathematics, literature, and perhaps other disciplines as well. (Received September 21, 2010)

1067-T1-2223 **Sheila K. Miller*** (sheila.miller@colorado.edu), 646 Swift Road, West Point, NY 10996. *On the Value of Doubt and Discomfort.*

To present mathematics as completely devoid of any of its relevant philosophical issues is to detach it from one of its principal sources of power to captivate and persuade. Deep learning is uncomfortable; when something causes us to question a belief we hold about the universe, our minds struggle and shift to find resolution. Many students come to college convinced that mathematics is a static subject safe from doubt and uncertainty. One gateway to an improved understanding of the field of mathematics is the discovery that there is a difference between truth and provability. These notions are definable in any course (with varying degrees of rigor), and the reality that there are limits to what can be known mathematically can be shocking, unsettling, and compelling. This talk will address how and why I discuss Gödel's Incompleteness Theorems and Cantor's Diagonalization argument in every course I teach. (Received September 22, 2010)

1067-T1-2224 **Whitney Johnson***, 2226A Benjamin Building, University of Maryland, College Park, MD 20742, and **Bill Rosenthal**. *Precalculus from an Ontological Perspective.* Preliminary report.

Universities are struggling with the large number of students who place into classes below calculus and perform poorly. We posit that one factor underlying this problem is inattention to ontological issues - in particular, the very existence of the mathematical objects under study. A tacit assumption in most mathematics textbooks is that a clear definition of an object is ontologically sufficient for conceptualizing and operating with that object. We wish to disinter and examine this assumption. It is reasonable to conjecture that, to someone who questions the existence of an object, a definition of utter clarity may not suffice. Definitions address the question, "What is it?" - presupposing that, indeed, it is. Definitions do not address the primal question, "Is it?" Professional mathematicians, who hold the power to create objects of study by sheer will, need not bother with the latter query. Students fresh out of high school are unlikely to be so philosophically fortunate.

Each of us teaches precalculus, one at an urban community college, the other at a research university. As a case in point, we consider the ontological content of precalculus as inferred from textbooks, cross-referencing the findings with insights drawn from studies of our students' work. (Received September 22, 2010)

1067-T1-2300 **Firooz Khosraviyani*** (FiroozKh@TAMIU.edu), 5201 University Boulevard, Laredo, TX 78041-1900, **Terutake Abe** (tabe@southtexascollege.edu), 3201 West Pecan Blvd., McAllen, TX 78501-6661, and **Juan J Arellano** (juan.arellano@tamiu.edu), 5201 University Boulevard, Laredo, TX 78041-1900. *Definitions in Their Developmental Stages: What should we call them?* Preliminary report.

In an axiomatic system, such as in much of modern Mathematics, terminologies such as definitions, theorems, lemmas, corollaries, propositions, and conjectures have specific uses to more effectively communicate their purpose. They fall into two categories depending on the role they play: organizational and developmental (related to the process of creating). The organizational terms further fall into two subcategories: definitional (definitions) and consequential (theorems, etc.). Correspondingly, the developmental terms should also fall into these two subcategories. But, though the existing mathematical literature has made an extensive use of the theorems in their developmental stages (conjectures), it has not done the same with definitions in their developmental stages. In these notes, we discuss ways to address this observable deficiency in the set of standard terminologies in Mathematics. (Received September 22, 2010)

1067-T1-2327 **Andy D. Martin*** (andrew.martin@kysu.edu), Carver Hall 113 B, Kentucky State University, Frankfort, KY 40601. *Claims Become Theorems, but Who Decides?* Preliminary report.

How do claims of proofs become theorems and join the patchwork tapestry of mathematics we admire and try to describe to our students? Who actually decides for us when a very difficult proof is correct? Surely something like a vote occurs, with acknowledged experts the electors. Is my telling my students the Poincare Conjecture is settled more like a newscast or the Emperor's New Clothes (where I stand at the roadside as the naked ruler passes and assert that I, too, see his beautiful garments)? How can I KNOW that it is true?

Reuben Hersh's view of mathematics as a socio-cultural construct certainly seems to describe this aspect of the mathematical world well. What then is the wisest attitude to have when hearing unverifiable claims? Surely not naive acceptance. What attitude should we foster in our students? (Received September 22, 2010)

The Scholarship of Teaching and Learning in Collegiate Mathematics

1067-V1-30 **Gregory A Kelsey*** (gkelsey2@illinois.edu), 300 S. Goodwin Ave., Apt. 609, Urbana, IL 61801. *Group Work and Self-Efficacy in a Business Calculus Class.*

In a business calculus course with lecture and discussion sections, TAs ran half the discussion sections in the standard format and half in a group work format. At the beginning and end of the semester, students completed brief surveys indicating their confidence in their ability to perform mathematical procedures and their ability to learn new mathematics. The changes in the reported learning self-efficacy of the students in the group work sections correlated strongly with their final course grades, unlike in the standard sections. This suggests that while group work may not increase students' learning self-efficacy, it might improve the accuracy. (Received June 06, 2010)

1067-V1-52 **Aubrey D. Magoun*** (magoun@ulm.edu), Department of Mathematics, ULM, Monroe, LA 71209, **David Hare** (hare@ulm.edu), Department of Mathematics, ULM, Monroe, LA 71209, and **Charlotte H. Owens** (owens@ulm.edu), Department of Mathematics, ULM, Monore, LA 71209. *The Effects of NCAT's Redesign on Student Learning in Beginning Statistics.*

Mathematics classrooms at many universities have incorporated new approaches to student learning using redesign policies advocated by the National Center for Academic Transformations' (NCAT) roadmap to redesign (R2R). This article discusses the results of a well-designed classroom experiment involving students in beginning statistics, a general education course designed to meet core freshman mathematics requirements. The study involved three instructors randomly assigned to two of six sections. Each instructor taught one section using technology and an additional section using standard face-to-face teaching practices. The infusion of the technological component advocated by NCAT significantly improved student scores on the common, comprehensive final examination. (Received June 25, 2010)

1067-V1-203 **Kimberly Santucci Sofronas*** (sofronki@emmanuel.edu), Emmanuel College, 400 The Fenway, Boston, MA 02115, **Thomas C DeFranco** (tom.defranco@uconn.edu), Storrs, CT, **Charles Vinsonhaler** (charles.vinsonhaler@uconn.edu), Storrs, CT, **Nick Gorgievski** (nick.gorgievski@nichols.edu), Dudley, MA, **Larissa Schroeder** (schroeder@hartford.edu), West Hartford, CT , and **Chris Hamelin** (chris.hamelin@huskymail.uconn.edu), Storrs, CT. *What Does it Mean for a Student to Understand the First-Year Calculus?: Perspectives of 24 Experts.*

This paper presents the views of 24 nationally recognized authorities in the field of mathematics, and in particular the calculus, on student understanding of the first-year calculus. A framework emerged from this study that includes four overarching end goals for understanding of the first-year calculus: (a) mastery of the fundamental concepts and skills, (b) construction of connections and relationships between and among concepts and skills, (c) ability to use the ideas of the first-year calculus to solve problems, and (d) understanding of the context and purpose of the calculus. The framework may serve as an organizational tool that links together a number of disparate studies from the research literature. Organizing the body of prior research around a framework of core goals that define student understanding of the first-year calculus may have a number of practicable outcomes that have potential to further promote student understanding. These include identification of end goals and related sub-goals in need of further study or yet to be researched; synthesis of what is known about students' areas of misconception and cognitive difficulty as they relate to end goals and sub-goals outlined in the framework; shaping of instruction in ways that consider those problem points. (Received August 02, 2010)

1067-V1-411 **Carrie Muir*** (Carrie.Muir@Colorado.edu), 395 UCB, Boulder, CO 80309-0395. *Changing Scales, Changing Perspectives.*

At most U.S. colleges and universities, students' end of term grades are reported in terms of grade-points, with letter grades represented as even increments on the zero to four scale. Yet much of mathematics coursework is graded on a percentage-based scale, upon which final letter grades are determined in a not always systematic manner. In this talk, I will outline why and how I changed my grading system for an undergraduate linear algebra course to a grade-point model. I will present sample student assignments and multi-semester student outcomes data to demonstrate the effects this administrative change had on student performance. I will also discuss how this policy change and my students' responses to it affected how I view the activities of grading and providing feedback. (Received September 01, 2010)

1067-V1-485 **Jerry C. Obiekwe*** (Accessx@uakron.edu), P.O. Box 411, Orrville, OH. *Mathematical Word Problems: An Instructional Approach that evolved from its Cognitive Complexities.*

Word problems are probably one of the most challenging topics in college algebra for a great many students. Consequently, the instructional strategy that is employed in teaching this topic becomes paramount in making the subject matter more understandable to students. According to Mayer, Larkin & Kadane (1984), the solution to mathematical word problems have essentially four phases, and each phase has certain knowledge requirement. Failure to take a mathematical word problem from start to a correct solution can be attributed to lack of appropriate knowledge requirement of any one of those phases. Perhaps the application of this knowledge from cognitive psychology regarding mathematical problem solving combined with psychometric methods could help to address some of these issues. Cognitive psychology provides the cognitive model for the problem solving, while the psychometric methods address how to detect and control the sources of the difficulties in solving math problems. This study will first discuss the validation procedure of the four phases of mathematical word problems and secondly its implications to teaching and learning of this subject. (Received September 06, 2010)

1067-V1-863 **Robert Hoar** (hoar.robe@uwlax.edu), 1725 State Street, La Crosse, WI 54601, **Jennifer Kosiak** (kosiak.jenn@uwlax.edu), 1725 State Street, La Crosse, WI 54601, **Karoline Auby*** (auby.karo@uwlax.edu), 1725 State Street, La Crosse, WI 54601, and **James Sobota** (sobota.jame@uwlax.edu), 1725 State Street, La Crosse, WI 54601. *A Collaborative Process for Developing Digital Learning Materials: An Analysis of Student Performance and Feedback.*

Utilizing processes developed by the Institute for Innovation in Undergraduate Research and Learning (IIURL), teams of students, faculty and staff have developed a collection of media-rich learning objects which are being used in a variety of undergraduate mathematics courses. Recently, a subset of these learning objects has been packaged into an online College Algebra Credit-by-Exam "prep" course. This collection is designed to strengthen the algebraic skills of incoming freshmen in order to better prepare them for a college algebra final exam, which they will take during the second week of the semester. These learning objects also have served as a means to re-familiarize students with the background knowledge needed for successful completion of higher level coursework.

The process by which this collaborative project has unfolded will be discussed and the resulting learning objects will be presented. An analysis of the data collected relating to student perceptions (survey), student involvement (time on task data) and performance (exam and later course outcomes) will be presented. (Received September 15, 2010)

1067-V1-1151 **Brad Bailey*** (bbailey@northgeorgia.edu), 82 College Circle, Dept. of Mathematics & Computer Science, Dahlonega, GA 30597. *Effects of a Modified Moore Method on Performance, Attitudes and Efficacy in Precalculus.*

The researchers conducted a year-long quasi-experimental study on the effects of the Moore method versus lecture methods in Precalculus, a freshman level course in mathematics. Our experiment involved three instructors and was conducted over two semesters, with both teaching methods used during each semester, and with each instructor teaching one control and one treatment section, thus providing a control/treatment design for both semester and instructor. Near the beginning and end of each semester, all the students completed a survey which included questions about grade efficacy and task-efficacy as well as a subset of the attitudes and beliefs construct of Shoenfeld (1989). To assess and compare the students' performance in the course, all students took a common final exam. In this talk, the speaker will describe the study itself and outline the study's statistically significant findings, which include higher final exam scores and increased mathematical maturity for the students in the Moore Method class. (Received September 19, 2010)

1067-V1-1413 **Marilyn Reba***, Department of Mathematical Sciences, Martin Hall, Clemson University, Clemson, SC 29631, **Allen Guest**, Department of Mathematical Sciences, **Calvin Williams**, Department of Mathematical Sciences, and **Roy Pargas**, Department of Computer Science. *Implementing a Web-based System for Tagging Errors in Freshman Calculus Using Pen-Technology.*

Pen-technology enabled the construction of a large database of student work in Calculus which motivated the tagging and analysis of student errors and problem-solving strategies. To minimize failure rates, we want to know where students in at-risk groups, and students in general, are making errors and then, guided by an extensive statistical error analysis, develop and evaluate new teaching materials and online instructional interventions. For example, is it accurate to say that the precalculus preparation of transfer students is responsible for their high DFW rates in Calculus I? Through collaboration between the Department of Mathematical Sciences and the Department of Computer Science, funded both by Hewlett Packard and NSF, we have been able to enhance the web-based software, MessageGrid, to meet the needs of this tagging project. The process of developing an error-analysis study based on tagging involves the interplay of several components, including the development of a tagging lexicon. In Summer 2010, several faculty members and graduate students developed a lexicon of errors and tagged thousands of pages of Calculus I finals from Fall 2009. We report on the process and our initial findings. (Received September 20, 2010)

1067-V1-1490 **Dale J Winter*** (amanita@andrew.cmu.edu), 5000 Forbes Avenue, Pittsburgh, PA 15213.
Re-testing as a strategy to promote equity.

Promoting equity by closing achievement gaps in mathematical performance represents a significant challenge at both K-12 and undergraduate levels (Carey et al., 1995; Fullillove & Treisman, 1990; Sax, 1994). Prominent teacher-scholars have suggested that re-testing may promote performance equity (Nelson, 1996). Under this system, students to take a regularly scheduled exam. After the graded exam is returned, and further study, students may take a different exam over the same body of material. This practice may allow students to engage in realistic practice, receive feedback, observe performance standards, overcome anxiety and raise skills and understanding to the expected level for the course. This talk will report the results of a study on re-testing, performance and equity in service mathematics courses. The study included 5 courses, 826 students and focused on performance gaps associated with gender, ethnicity and academic intensity of high school preparation. Results suggest that re-testing may be an effective strategy for eliminating gaps associated with gender and high school academic intensity. Gaps associated with ethnicity closed but were not eliminated. (Received September 21, 2010)

1067-V1-1516 **Gretchen Rimmasch*** (rimmaschg@suu.edu), 351 W University Blvd., Cedar City, UT 84720, and **Jim Brandt** (brandt@suu.edu), 351 W University Blvd, Cedar City, UT 84720.
Using Visual Cues in Teaching Computational Skills.

Visual cues provide a tool to assist students in recognizing and applying symbolic rules while offering opportunities to strengthen conceptual understanding. The results of a classroom teaching experiment involving visual cues in teaching exponent rules will be presented. The cues were designed to increase computational skill while also drawing connections with other mathematical topics. Pre-test and post-test surveys were administered to two sections of intermediate algebra students, one as a control group and the other as a treatment group. The treatment group showed a greater improvement in computational fluency, and the difference was statistically significant. Possible uses of visual cues to the teaching of other mathematical topics will be discussed. (Received September 21, 2010)

1067-V1-1612 **Erich A McAlister*** (mcalister_e@fortlewis.edu), Department of Mathematics, Fort Lewis College, 1000 Rim Dr., Durango, CO 81301. *Designing Precalculus for a Diverse Audience.*

In this talk we will discuss various aspects of a course redesign of Precalculus at a small public liberal arts college with a large Native American student population. Because of a very wide range of student preparedness, this course has traditionally been problematic due to low student success rates among STEM majors. Redesign of the course included adjustment of the curriculum, changes in in-class assessment methods, and implementation of online assessments. Analysis of the success of this course redesign will include analysis of student learning, success rates, and student attitudes. This work was funded by a U.S. department of Education Title III grant. (Received September 21, 2010)

1067-V1-1900 **Judith Lynn Gieger*** (lgieger@oglethorpe.edu), 4484 Peachtree Rd. NE, Atlanta, GA 30319, **John C. Nardo** (jnardo@oglethorpe.edu), 4484 Peachtree Rd. NE, Atlanta, GA 30319, **Karen L. Schmeichel** (kschmeichel@oglethorpe.edu), 4484 Peachtree Rd. NE, Atlanta, GA 30319, and **Leah R. Zinner** (lzinner@oglethorpe.edu), 4484 Peachtree Rd. NE, Atlanta, GA 30341. *A quantitative and qualitative comparison of homework structures in a multivariable calculus class.* Preliminary report.

The purpose of this study was to investigate the relative effectiveness of an online homework assessment structure in a multivariable calculus class. In previous semesters, this course utilized a traditional textbook homework assignment system, with occasional problems collected and graded by the professor. While this traditional structure was effective in providing students with feedback in preparation for exams, it was believed to be less effective in terms of enforcing regular daily practice of calculus skills. In the most recent semester, students completed homework problems using an online program that required them to continue to solve problems until they reached a specified level of mastery. We measured outcomes both quantitatively (pre- and post-semester surveys of student behaviors, motivations and attitudes; grade comparisons between the group currently enrolled in the course and a group enrolled in a previous semester) and qualitatively (focus groups with a semi-structured interview protocol and multiple coders). The results of this study (completed in December 2010) will be used to inform future decisions regarding homework structures, particularly as related to academic progress in the course as well as engagement with mathematical ideas. (Received September 22, 2010)

1067-V1-1918 **Carrie A Campbell*** (aicarriecampbell@gmail.com). *Learning Effects of Examples Applied to College Algebra Student Interests.*

This investigation studied the learning effects of example problems based on college algebra student interests. The study spanned two semesters and included three groups of students. The first group was presented with algebraic procedural examples and assessments without context. The second group was presented with algebraic class examples in contexts related to student majors and hobbies, but assessments without context. The third group was presented with class examples in contexts related to student majors and hobbies and also assessments with context.

Learning growth as measured by performance scores on examinations was analyzed quantitatively. Performance improvement was higher for Group 3 than for Group 2 than for Group 1 as context increased, but these most differences were not statistically significant and could have occurred by chance. A large effect size (>0.80) between Group 3 students presented with class examples and homework problems based on student interests and Group 1 (control) students for 50% of quizzes given.

Student engagement was also studied. Results from scaled student survey including questions from the National Survey of Student Engagement were analyzed quantitatively. (Received September 22, 2010)

1067-V1-1998 **Hortensia Soto- Johnson** (hortensia.soto@unco.edu), CO, **Sarah Rozner*** (sarah.rozner@unco.edu), CO , and **Kristin Noblet** (kristin.noblet@unco.edu), CO. *Comparing geometry curriculums: The impact on pre-service elementary teachers' pedagogical content knowledge.* Preliminary report.

To gain an understanding of how pre-service elementary teachers understand geometry content, pedagogy, and PK-8 geometry curriculum we compared two different curriculums that four instructors implemented over six sections. We conducted a mixed method study in order to explore this phenomenon. All six instructors implemented a pre-test and administered common questions on their final exams, which allowed for a comparison across instructors and curriculums. Additionally, some students participated in interviews in order to triangulate our findings and gain insight into these pre-service teachers understanding of their PK-8 pedagogical content knowledge in geometry. This will be a preliminary report of our findings. (Received September 22, 2010)

1067-V1-2088 **Rebecca J. Schmitz*** (schm2676@umn.edu), MathCEP, 4 Vincent Hall, 206 Church Street SE, Minneapolis, MN 55455, and **Harvey Keynes** (keynes@math.umn.edu), MathCEP, 4 Vincent Hall, 206 Church Street SE, Minneapolis, MN 55455. *Student learning and retention of key concepts in sequences and series.*

This paper further explores student understanding of key concepts in sequences and series including the understanding of infinite repeating decimals and their connections to infinite series. In addition to talented high school students in honors University calculus, we look at several standard and honors freshman and sophomore calculus and post-calculus courses and examine students' pre- and post-instructional knowledge. The data obtained indicates significantly differing levels of understand before and after instruction as well as differing levels of gain. These results have implications for the structure and teaching of bridge courses to higher-level mathematics. Finally, there is additional evidence that conceptual approaches to teaching and learning result in better retention of these ideas. (Received September 22, 2010)

1067-V1-2119 **Erin Terwilleger Mullen*** (erin.terwilleger@uconn.edu), Department of Mathematics, U-3009, University of Connecticut, Storrs, CT 06269, and **Amit Savkar** (amit.savkar@uconn.edu), Department of Mathematics, U-3009, University of Connecticut, Storrs, CT 06269. *A comparison of two paths in college level calculus.* Preliminary report.

The department of Mathematics at the University of Connecticut recently restructured its first year calculus sequence. There are now two paths the students can take; first is the traditional Calculus I course, and second is a slower two semester sequence which covers the same material with more emphasis on precalculus. Both of these lead into a traditional Calculus II. The goal of this research is to compare the student learning of calculus in these two different paths and how it affects performance in Calculus II. In addition, we will study the impact of students' previous math experience in high school on their performance in college level calculus.

To assess the student learning in these two pathways, we will compare the grades of the students on common questions on the final exam. We intend to understand the students' perception of their learning by comparing knowledge surveys given and the beginning and end of the semester. To assess the performance of the two populations in Calculus II, we are using a pre-test over Calculus I material given at the beginning of the semester and questions on the final exam. This past spring we collected the initial set of data of the four semester long project, and we will give preliminary results. (Received September 22, 2010)

1067-V1-2147 **Francesco J. Echeverria** (chevyphysics@yahoo.com), 6704 Cabin Creek Drive, Colorado Springs, CO 80923, and **James S. Rolf*** (jimrolf@yahoo.com), 1333 Culebra Avenue, Colorado Springs, CO 80903. *The Use of Videos to Encourage Pre-Class Preparation.* Preliminary report.

We discuss the use of short videos to encourage student preparation prior to coming to class. These videos are given to students prior to selected lessons with the expectation that students preview the video, read a short selection from the text, and solve a problem related to the content of the video. We compare student performance on in-class quizzes between video and non-video lessons. We also compare student performance on exams between students who had access to videos with those who did not. (Received September 22, 2010)

1067-V1-2246 **Curtis D. Bennett*** (cbennett@lmu.edu), Department of Mathematics, 1 LMU Drive, Suite 2700, Los Angeles, CA 90045, **Suzanne Larson** (slarson@lmu.edu), Department of Mathematics, 1 LMU Drive, Suite 2700, Los Angeles, CA 90045, and **Laura J. Massa** (lmassa1@lmu.edu), 1 LMU Drive, Room 3029, Los Angeles, CA 90045. *An analysis of student understanding of voting power in a a quantitative literacy class.* Preliminary report.

This talk is a preliminary report on our analysis of student learning of the concept of voting power. In fall 2008, we taught a unit on voting power in a quantitative literacy class consisting of students playing a game involving weighted voting and then on another day discussing the Electoral College and the Banzhaff Power of the states in the Electoral College, and finally calculating the power of individual voters from each state. As a final project students wrote a letter to the editor in favor of or against the Electoral College. In this talk we will give a preliminary report of the analysis of student understanding of voting power based on their letters to the editor and answers to questions on the final exam. (Received September 22, 2010)

Treasures from the Past: Using Primary Sources in the Classroom

1067-W1-239 **Colin Bryan Powell McKinney*** (cmckinney@bradley.edu), Department of Mathematics, Bradley University, Peoria, IL 61625. *Isaac Barrow's Proof of the Fundamental Theorem of Calculus.*

In his *Geometrical Lectures*, Isaac Barrow gives a very geometric proof of what we now call one version of the fundamental theorem of calculus. I will give the details of his proof and discuss how his version can make the abstract statement of the fundamental theorem more concrete for students. (Received August 11, 2010)

1067-W1-375 **Jeff Suzuki*** (jeff_suzuki@yahoo.com), 2900 Bedford Ave., Brooklyn, NY 11210. *Mathematics of Non-Western Civilizations: A New Course for Majors and Nonmajors Alike.*

Recently we developed a course on the mathematics of nonwestern civilizations to provide an upper level liberal arts mathematics course that satisfies a college requirement for global connections. Intended for majors and non-majors alike, the course uses translated primary sources as a vehicle for investigating the mathematics of other cultures. We will examine some of the successes (and failures) of this course, as well as its further potential. (Received August 30, 2010)

1067-W1-617 **Andrew Simoson*** (ajsimoso@king.edu), King College, 1350 King College Road, Bristol, TN 37620. *Newton's subjunctive G-flat opus.*

Appropriate for a vector calculus class when studying triple integration, we look at Newton's flattening of the earth problem of problem 3, book 3 of his *Principia* where he estimates the difference Δr in earth's polar and equatorial radii. In particular Newton states this result: for a uniform density ellipsoid "deprived of all its motion" with polar to equatorial radius as 100 is to 101, then the gravity at the north pole to the gravity at a point on the equator is 501 to 500. Although Newton refers to his solution process as "making the computation" he is really evaluating at least two triple integrals, one of which must be approximated. We set up and evaluate the integration, and then repeat the process using a two-tier density (and more realistic) model of the earth—a model that involves knowing G, the universal gravitational constant, first determined by Cavendish in 1798.

Will the improved model give a better estimate than Newton's guess of 17.1 miles for Δr? The actual value for Δr is 13.3 miles. (Received September 11, 2010)

1067-W1-659 **William Dunham*** (wdunham@muhlenberg.edu), Department of Mathematics and CS, Muhlenberg College, Allentown, PA 18104. *Partial Fractions in Euler's Institutiones calculi differentialis.*

Our standard approach to the partial fraction decomposition of rational functions is an algebraic one that leads to the solution of multiple equations in multiple unknowns. There is something natural about this procedure, which Euler discussed in his classic Introductio in analysin infinitorum from 1748. But in his 1755 differential calculus text, Euler described an alternative approach that cleverly employs calculus in the service of algebra. We shall look at the technique as he presented it and at some examples he used to demonstrate its utility. (Received September 13, 2010)

1067-W1-1048 **Andy D. Martin*** (andrew.martin@kysu.edu), Dr. Andrew Martin, Carver Hall 113B, Kentucky State University, Frankfort, KY 40601. *Reviewing Logs through the Resolution of Two Different Published Algebraic Representations of Napier's Logarithm.*

Two popular History of Mathematics ([2],[3]) texts agree on what algebraic form represents the logarithm as defined by Napier, but a third ([1]) has something different. Why don't they agree? Which is correct ? Are the representations equivalent ? If not, how are they related? Does either exhibit the "logarithmic" properties of turning products into sums and quotients into differences?

After describing Napier's definition, this talk will address these and related questions, which the speaker has assigned students (and will again) as a nonstandard way to review properties of logarithms.

[1] Boyer, Carl A History of Mathematics, Wiley and Sons, 1968. [2] Eves, Howard An Introduction to the History of Mathematics , 5th ed, Saunders College Publishing 1983. [3] Katz, Victor A History of Mathematics: An Introduction , HarperCollins 1993. (Received September 17, 2010)

1067-W1-1184 **Osama O. Taani*** (osama@nmsu.edu), 1011 Wooten Dr, Las Cruces, NM. *Multiple Paths to Mathematics Practice in al-Kashi's Key to Arithmetic: A Preliminary Report.* Preliminary report.

In this paper, I discuss one of the most distinguishing features of Jamshid al-Kashi's pedagogy from his Key to Arithmetic, a well-known Arabic mathematics textbook from the fifteenth century. This feature is the multiple paths that he includes to find a desired result. We show four different examples of his versatility in presenting a topic from multiple perspectives. These examples are multiple definitions, multiple algorithms, multiple formulas, and multiple methods for solving word problems. I look at possible implications for modern curricula. (Received September 22, 2010)

1067-W1-1475 **Janet Heine Barnett*** (janet.barnett@colostate-pueblo.edu), Department of Mathematics and Physics, Colorado State University - Pueblo, 2200 Bonforte Blvd, Pueblo, CO 81001-4901. *Abstract awakenings in algebra: Teaching and learning group theory through the works of Lagrange, Cauchy, and Cayley.*

The seeds of group theory can be recognized in several early nineteenth century mathematical developments. The common features of these apparently disparate developments were first explicitly recognized by Arthur Cayley (1812–1895). In his 1854 paper "On the theory of groups, as depending on the symbolic equation $\theta^n = 1$," Cayley defined a group as any (finite) system of symbols subject to certain algebraic laws, stated several important group theorems and proceeded to classify groups up to order seven. Although focused on general properties of arbitrary groups, Cayley motivated his work through references to specific nineteenth century appearances of the group concept. As a result, his paper provides a powerful lens on the process and power of mathematical abstraction.

In this talk, we examine a student module that uses excerpts from Cayley's own paper, together with pre-Cayley sources which frame its historical and mathematical context, as a means to develop elementary group theory in an undergraduate course. Results of classroom-testing and an overview of the rationale which guides the NSF-funded project *Learning Discrete Mathematics and Computer Science via Primary Historical Sources* that supported its development will also be presented. (Received September 21, 2010)

1067-W1-1531 **Stuart Anderson*** (stuart_anderson@tamu-commerce.edu), 3000 South Neal, Commerce, TX 75429. *From Babylonian Table Texts to Abstractions.*

A common occurrence in beginning algebra courses is for a student to "guess" the correct answer to a problem. This can cause the student to be reluctant to learn more abstract methods that would apply to many similar problems. This paper uses an examination of ancient Babylonian table texts, and modern spread sheets, to demonstrate the need to progress from trial and error to more advanced forms of problem solving. (Received September 21, 2010)

1067-W1-2132 **Andrius Tamulis*** (a-tamulis@govst.edu), Governors State University, 1 University Parkway, University Park, IL 60484. *The Mathematics of Albrecht Dürer.*

Written in 1525, Albrecht Dürer's *Painter's Manual* was written to introduce Renaissance art techniques to German artists. As was common at the time, however, both the author and the intended audience of this text had a solid mathematical education and so Dürer's *Painter's Manual* is contains a wealth of mathematics. Topics he included are suitable for use in algebra, calculus, differential equations, geometry, and quantitative reasoning classes. Aided by H. Staigmüller's "Dürer als Mathematiker" - practically a primary source in itself, as it was written in 1891 - we will see classroom materials for algebra through differential equations courses based on several curves as they were described by Dürer. We will also see classroom materials based on geometric proofs from Dürer's investigations of the Delian problem. (Received September 22, 2010)

1067-W1-2153 **Bruce S. Burdick*** (bburdick@rwu.edu). *Treasures from the Americas: Two Examples of Arithmetic as It Is No Longer Done.* Preliminary report.

We present two examples dealing with fractions, drawn from early printed works in the Americas, one from Peru and one from Mexico.

The *Libro General* of Joán Belveder was printed in Lima in 1597 and is an extensive treatment of how to do transactions in gold and silver. One of his more interesting sections explains how to use money to express fractions. (We infer that he judged that his intended readers would understand money much better than they understood fractions.) Percents and fractions of a percent are presented as *pesos*, *tomines*, *granos*, and parts of a *grano*.

In the *Arte para Aprender* (Mexico City, 1623), Pedro de Paz declares that there is a new operation on fractions in addition to the usual four operations of arithmetic. He uses the term "to *infilzar* the fractions" and indicates that he takes this term from Italian sources.

Both examples should be accessible to students with only a strong arithmetic background. Both make the point that there are other ways of doing the math we do and thus they promote a flexible mindset in the student. (Received September 22, 2010)

Trends in Undergraduate Mathematical Biology Education

1067-X1-700 **Timothy D Comar*** (tcomar@ben.edu), Department of Mathematics, Benedictine University, 5700 College RD, Lisle, IL 60532. *Motivating the Biology in Biocalculus Courses.*

The biocalculus courses at Benedictine University are designed to provide quantitative techniques and approaches that will be useful to students majoring in the biological and health sciences in their future coursework and careers. There is a particular emphasis on students interested in pursuing research. The courses use a threefold approach integrating mathematics, biology, and the use of computational software to investigate biologically oriented problems. This presentation will focus methods used to motivate the biological content in these courses, including using the reading of journal articles, computer activities, and course projects. We conclude with a discussion of student feedback and student research involvement after completion of the course sequence. (Received September 13, 2010)

1067-X1-812 **Aaron Luttman*** (aluttman@clarkson.edu), Box 5815, Clarkson University, Potsdam, NY 13699. *Mathematics, Biology, and Imaging: Engaging Undergraduates in Research on the Fringe of Mathematical Biology.*

There is a great deal of active research that mixes mathematics, biology, and imaging, but almost all such projects lie within the field of "medical imaging." There are, in fact, great applications of imaging science – and its mathematical components, in particular – to the study of a wide range of biological applications that lie way outside the medical regime. In this presentation we will introduce and describe three undergraduate research projects at an unusual interface between mathematics, biology, and imaging. The first project involved using the same imaging techniques based on partial differential equations to analyze both leaf transpiration and the flow of oceanic plankton blooms. The second project centered on image-based methods for analyzing periodicities in tree ring growth, and the third incoporated methods from computer vision to classify cryptic species of southeast Asian lizards. The students' research results will be described, with a focus on how to engage students in such "fringe" projects, how to fund them, and how to find the appropriate collaborators from the biological sciences to work with. (Received September 15, 2010)

1067-X1-1361 **Kaibin Fu*** (kafu@pvamu.edu), Department of Mathematics, Prairie View A&M University, Prairie View, TX 77446. *Integrated undergraduate research experiences in biological and mathematical sciences for minority students.* Preliminary report.

Prairie View A&M University(PVAMU), a member of Historically Black Colleges and Universities(HBCU), has been recently awarded a 5-year UBM grant from NSF. This is a collaborative work with Texas A&M University(TAMU). We will talk about how to incorporate experiences and expertises on undergraduate research from TAMU into an institute for underrepresented students. We will also discuss the possible curriculum development at PVAMU along the interface of mathematics and biology. (Received September 20, 2010)

1067-X1-1424 **Kelly E Matthews*** (k.matthews1@uq.edu.au), University of Queensland, TEDI (96), Brisbane, QLD 4072, Australia, and **Peter Adams** and **Merrilyn Goos**. *Integrating mathematics and the life sciences to better prepare graduates for medical school.*

There is widespread agreement that Quantitative Skills (QS) are essential for graduate competence and preparedness in the sciences (NRC, 2003; Bialek and Bostein, 2004; AAAS, 2010), and this is not limited to just those students pursuing a career in scientific research. For example, medical schools (the destination of choice for many science undergraduates) are also emphasising quantitative skills (AAMC, 2009). While many institutions are responding to the 'calls for action', evidence of student learning is now needed to determine the success and on-going implementation of these responses. A large research-intensive university in Australia aims to instil greater QS through implementation of a new science curriculum, including introductory science-mathematics courses, undergraduate research courses, and final year capstone courses that require biology majors to integrate and apply their QS. This paper will present findings from the first cohort of students graduating from the new curriculum, focusing on the preparedness and abilities of graduates going on to study medicine. Data will be presented from student-self reporting via a graduating skills inventory and performance data from a QS assessment task. (Received September 21, 2010)

1067-X1-1461 **Padmanabhan Seshaiyer*** (pseshaiy@gmu.edu), 4400 University Drive, MS:3F2, Mathematical Sciences, George Mason University, Fairfax, VA 22030, and **Maria Emelianenko**. *Transformative Research and Training in biological and bio-inspired systems in undergraduate mathematics.* Preliminary report.

In this work we present results from projects that evolved from a multidisciplinary undergraduate research program in mathematical modeling of biological and bio-inspired systems. This work emphasizes the importance of fostering integration of interdisciplinary research in mathematical sciences to help explain fundamental mechanisms underlying real-world biological problems, thereby enhancing the effectiveness of teaching and learning of undergraduate mathematics. Such transformative research automatically provides opportunities for undergraduate mathematics majors to perform research in areas that bridge the gap between mathematical and biological sciences. (Received September 21, 2010)

1067-X1-1588 **Jeff R Knisley*** (knisleyj@etsu.edu), Box 70663, Dept of Mathematics, East Tennessee State University, Johnson City, TN 37614-0663. *Addressing the Revision of the MCAT Within the Symbiosis Project.*

In approximately January of 2014, the American Association of Medical Colleges (AAMC) will release a major revision of the Medical College Admissions Test (MCAT). Many of the changes in the MCAT are motivated by the report "AAMC-HHMI Foundations for Future Physicians," which includes several new or revised competencies in quantitative biology and biostatistics. These competencies are especially important to the Symbiosis project, which is an introductory laboratory sciences quantitative biology sequence (under development at East Tennessee State University). In this talk, we discuss how the Symbiosis project is addressing the quantitative competencies associated with the revised MCAT, focusing on methods which can be integrated into mathematical biology curricula in general. (Received September 21, 2010)

1067-X1-1645 **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 requires participating students enroll in interdisciplinary, quantitative biology courses (modeling/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 have 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 21, 2010)

1067-X1-1660 **Richard Schugart***, Department of Mathematics & Computer Science, Western Kentucky University, 1906 College Heights Blvd #11078, Bowling Green, KY 42101. *Student Projects for the Mathematical Modeling of Wound Healing.* Preliminary report.

In this talk, I will provide a brief overview of a mathematical model that I formulated for the complex process of wound healing. I will highlight multiple undergraduate projects that a half-dozen students have worked on from the mathematical model that involve model stability analysis and model reformulation to either better reflect the biology or match data from the literature. I will briefly discuss how I think models like this can be used in undergraduate math-biology classes. (Received September 21, 2010)

1067-X1-1675 **Brian Arthur Christopher*** (brian.christopher@unco.edu), 501 20th Street, Campus Box 122, Greeley, CO 80639, and **Rebecca-Anne Dibbs** (rebecca.dibbs@unco.edu), 501 20th Street, Campus Box 122, Greeley, CO 80639. *An ethnographic case study of precision taught bio-calculus.*

Interdisciplinary courses are becoming more common in STEM fields as mathematics moves from catering more to service departments to other subjects. To understand the nature of interdisciplinary STEM courses, we conducted an ethnographic case study on two sections of bio-calculus courses. After over 200 hours of participant observation, which we supplemented by interviews with instructors and students, we found are that the practice of precision teaching can be used to assess students' prior knowledge before class, which allowed instructors to focus the instructional periods on the students' weak points. This focus along with group activities after lectures led to students gaining a deeper, richer understanding and connection between mathematics and biology. (Received September 21, 2010)

1067-X1-1689 **Pam J Ryan*** (pjryan@truman.edu), Department of Mathematics and Computer Scienc, 100 E Normal St, Kirksville, MO 63501. *Undergraduate Mathematical Biology Research at Truman State University.* Preliminary report.

Through an NSF grant, Truman State University has been able to fund cross-interdisciplinary teams of faculty and undergraduates to do mathematical biology research. Our team is considering an extension of Tajima's D statistic, which is used to analyze evolutionary trends of genetic data; in particular, is it used to determine if a population is increasing or decreasing in genetic diversity. However, it doesn't distinguish between genetic drift (random fluctuations in allele percentages) and selection. We applied Tajima's D statistic to synonymous (non protein-changing) and nonsynonymous (protein-changing) mutations separately to answer this question. Our team wrote computer software to simulate different types of evolutionary processes and then analyzed a sample of data to determine the type of selection pressure an organism was under. I will talk both about our research program in general and our specific project. (Received September 21, 2010)

1067-X1-1746 **Jason E Miller*** (millerj@truman.edu), 100 E Normal St, Kirksville, MO 63501. *Interdisciplinary Training in Mathematical Biology Through Team-based Undergraduate Research and Courses.*

Inspired by Bio2010 and leveraging institutional and external funding, Truman State University built an undergraduate program in mathematical biology with high-quality, faculty-mentored interdisciplinary research experiences at its core. These experiences taught faculty and students to bridge the epistemological gap between the mathematical and life sciences. Together they created the infrastructure that currently supports several interdisciplinary courses, an innovative minor degree, and long-term interdepartmental research collaborations. This talk describes how the program was built with support from the NSF UBM program, and it shares lessons learned that will help other undergraduate institutions build their own program. (Received September 21, 2010)

1067-X1-1894 **Semen Koksal*** (skoksal@fit.edu), Department of Mathematical Sciences, 150 W. Univ. Blvd., Melbourne, FL 32901, **D. Carroll** (dcarroll@fit.edu), Dept. of Biological Sciences, 150 W. Univ. Blvd., Melbourne, FL 32901, and **R. Sinden** (rsinden@fit.edu), Dept. of Mathemtical Sciences, 150 W. Univ. Blvd., Melbourne, FL 32901. *BioMath Program at Florida Tech: How to Sustain it?* Preliminary report.

In this talk, an overview of the UBM-Group activities will be given. Outcomes and the challenges of the newly established BioMath program will be presented. (Received September 22, 2010)

1067-X1-1968 **Sumona Mondal*** (smondal@clarkson.edu), 8 Clarkson Avenue, Potsdam, NY 13699. *Title of paper: Biology and Mathematics: The Exciting Nexus for the Advancement of Sciences.* Preliminary report.

Biomathematics and Biostatistics are building strong grounds these days. The reason is, these sciences bring mathematics to reality. Thus, the most important interdisciplinary training of modern days should be developed in such a way that it makes a good connection between biologists and mathematicians. The surge of this immense interest is because of the outcome of huge data from Biological experiments where as the ability to analyze them is limited. Invariably, there is a need of trained researchers who can help make sense of the data and present them most efficient way and consequently a team of researchers can create and implement new methods and techniques. Now comes the question of how to teach Biomath/Biostat to undergraduates from mathematics, biology and other interested majors? What courses we need to have? At what level the students should be taught so that we can raise a common interest? What pre-requisite courses should be considered? What kind of analytical tools to be adopted? What would be the role of a lecturer? In this presentation all these questions will be discussed. (Received September 22, 2010)

1067-X1-1979 **Sarah A Hews*** (shews1@swarthmore.edu), Department of Mathematics and Statistics, Swarthmore College, Swarthmore, PA 19081. *An Intro to Mathematical Biology Course for Biology Majors.*

Swarthmore College offered an Intro to Mathematical Biology class for the first time this fall to target biology majors with limited mathematical background and comfort. To reach this audience, the only prerequisite was Intro Bio. The fundamental goal for the course was for biology students to reach a mathematical literacy and to feel comfortable reading scientific journal articles containing mathematical models. To reach this goal, students manipulated models in computer labs, participated in in-class projects, and read, discussed, and critiqued three biological journal articles containing mathematical models. As a final project and measurement of the course goal, students self selected a modeling journal article to read, interpret, and critique. A description of the course, benefits and drawbacks of the course, and the results of students' pre/post surveys will be discussed in the talk. (Received September 22, 2010)

1067-X1-2047 **Carlos W Castillo-Garsow*** (cwcg@k-state.edu), Department of Mathematics, 138 Cardwell Hall, Kansas State University, Manhattan, KS 66506. *What do we mean when we say we "want students to understand exponential growth?".*

The exponential function is the most important function in mathematical biology, forming a foundation for differential equations, difference equations, and stochastic processes. However there is little research and only superficial agreement on how the subject of exponential growth should be taught. In order to investigate these issues, I preformed a teaching experiment in exponential growth with two high school students, leading up to the logistic differential equation model. During this experiment, both the students and I inadvertently used many different ways of thinking about change, rate of change, and exponential growth. Subtle differences in ways of thinking about exponential growth led to a great deal of miscommunication and incompatible – but not necessarily incorrect – results. In this paper. I highlight some of the ways of thinking used by participants in this teaching experiment. From these results I discuss how mathematicians teaching exponential growth make use of multiple contradictory ways of thinking, and the danger that these distinctions are not being communicated to students. (Received September 22, 2010)

1067-X1-2095 **Terrell L. Hodge*** (terrell.hodge@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008, and **Raina Robeva** (robeva@sbc.edu), Department of Mathematical Sciences, Sweet Briar College, Sweet Briar, VA 24595. *Mathematical Biology Modules Based on Modern Molecular Biology and Modern Discrete Mathematics.*

We describe an ongoing collaborative curriculum materials development project between Sweet Briar College and Western Michigan University with support from the National Science Foundation. We present a collection of modules under development that can be used in existing mathematics and biology courses and addresses a critical national need to introduce students to mathematical methods beyond the interface of biology with calculus. Influenced by recent research advances, the modules highlight applications of modern discrete mathematics and algebraic statistics to pressing problems in molecular biology. For some of the projects, calculus is not a required prerequisite, and the modest amount of mathematical background needed for the introductory parts of those modules makes them well-suited for an early introduction to mathematical modeling. At the same time, most modules are connected with topics in linear and abstract algebra, algebraic geometry, and probability, and can be used as meaningful applied introductions into the relevant advanced-level mathematics courses. Open-source software is used to facilitate the computations. (Received September 22, 2010)

1067-X1-2146 **Mazen Shahin*** (mshahin@desu.edu), Delaware State University, 1200 N. DuPont Highway, Dover, DE 19901. *Introduction to Mathematical Models in Biology.* Preliminary report.

In this paper we present some mathematical models in biology and ecology that illustrate the pedagogy and the approach utilized in a course being developed called Introduction to Mathematical Models in Biology. This one-semester course is designed for freshmen life science students and introduces modeling biological, ecological, and environmental systems with difference equations and matrices using a computer algebra system and/or spreadsheet. We emphasize the use of graphical and numerical techniques to investigate and analyze the behavior of solutions of the mathematical models. Group projects are AN integral part of the course and utilize cooperative learning. This course does not utilize differential equations and does not require calculus as a prerequisite. (Received September 22, 2010)

1067-X1-2148 **Ron Barnes*** (barnes@dt.uh.edu), CMS Department, 1 Main Street, Houston, TX 77002, and **Edwin Tecarro** (tecarroe@uhd.edu), CMS Department, 1 Main Street, Houston, TX 77002. *Short Courses in Biomathematics Topics for NSF Undergraduate Biology Mathematics Program (UBM Grant).* Preliminary report.

This paper describes a number of short courses, some with one semester hour of credit, that have been developed and presented by various mathematics and biology faculty to the research students taking part in a 5 year NSF funded proposal - Undergraduate Biology and Mathematics Program. The five courses that will be discussed briefly in this talk are: Introduction to Mathematical Biology, which describes the five areas of research in the UBM grant- which include studies of Wetlands characteristics; Fungi Distributions in Brays Bayou; Dynamical Systems Models; Biological Regulation with emphasis on Physiological Cycles; Multivariate Statistics including an overview of chi-square tests, correlation and regression,factor and cluster analysis;and Math Models for Biology using MATLAB with an emphasis on the logistic equation and Fibonacci sequences. (Received September 22, 2010)

1067-X1-2165 **Dmitry A Kondrashov*** (dkon@uchicago.edu), 924 E 57th St, University of Chicago, BSCD, Chicago, IL 60637. *Biomath is more than theorems with biological examples: an integrative framework.*

Modern biological science is increasingly quantitative, both because of large quantities of new data, and due to the complexity of the systems. It is generally accepted that biologists need better quantitative training, which serves the expanding needs of the science. I propose an approach to teaching mathematical topics for biologists, which consists of four components: model-building, analytical, computational, and biological. I will present implementations of this approach from two courses: Mathematical Methods for Biology for advanced students and a Biocalculus course for first-year biology majors. (Received September 22, 2010)

1067-X1-2181 **Patricia Theodosopoulos*** (ptheodosopoulos@saintannsny.org), 129 Pierrepont Street, Brooklyn, NY 11201, and **Ted Theodosopoulos** (ttheodosopoulos@saintannsny.org), 60 Wyckoff Street, Brooklyn, NY 11201. *The constructive role of noise in cellular processes.* Preliminary report.

In his classic "What is Life?" Schrödinger uses the evocative analogy of "aperiodic crystals" to describe the need for new ways to conceptualize randomness in living systems, beyond the realm of equilibrium statistical mechanics. We strive to convey this necessity to our students through a series of computational lab exercises, along with the partial answers that have been uncovered in the past sixty years. In our talk we will show the progression of simulation experiments we use to explore the role of noise in morphogenesis and cell differentiation, including current attempts to reverse this process and induce somatic cells to express their latent pluripotency. (Received September 22, 2010)

1067-X1-2221 **Brynja R. Kohler*** (Brynja.Kohler@usu.edu), Department of Mathematics and Statistics, 3900 Old Main Hill, Logan, UT 84322, and **Janice Bodily**, **Jessica Munns Davis**, **James Haefner** and **James Powell**. *Teaching Mathematical Modeling: Challenging Torricelli's Law.*

In this paper, we describe a laboratory modeling exercise and the teaching strategies we employ to successfully implement the project in our Applied Mathematics in Biology course. The laboratory is called the Leaky Bucket Lab and allows students to parameterize and test Toricelli's law and develop and compare their own alternative models to describe the dynamics of water draining from ordinary household containers with holes in the bottom.

This project also serves as an introduction to the epistemology and philosophy of science. (Received September 22, 2010)

1067-X1-2241 **Vrushali A Bokil*** (bokilv@math.oregonstate.edu), 368 Kidder Hall, Department of Mathematics, Oregon State University, Corvallis, OR 97331, and **Julia A Jones** (jonesj@geo.oregonstate.edu), 104 Wilkinson Hall, Department of Geosciences, Oregon State University, Corvallis, OR 97331. *Development and Implementation of an Undergraduate Honors Course on Mathematical Ecology.* Preliminary report.

In this talk we will describe the implementation of an undergraduate Honors College course in Mathematical Ecology offered at Oregon State University. The goals of this course are to attract students with a basic Calculus background to participate in a highly interdisciplinary environment, and to help them develop an appreciation for the use of mathematics in biological applications. The course offers topical lectures, discussions of research papers, interdisciplinary team projects, computational lab assignments, and expository/research based talks by guest faculty from diverse ecological, mathematical and computational fields. All these features provide a fertile environment for the understanding of mathematical concepts in ecology. In its fourth year, this course has led to the creation of other advanced courses in mathematical ecology, and has motivated past students to participate in Oregon State's summer institute (REU) in Ecoinformatics, IGERT program in Ecosystems Informatics, as well as pursue a graduate education in mathematical biology. (Received September 22, 2010)

1067-X1-2268 **Urmi Ghosh-Dastidar*** (ughosh-dastidar@citytech.cuny.edu), Namm 711, 300 Jay St., Brooklyn, NY 11201. *Undergraduate Student Mentoring – Minority Participation, Retention, Motivation for Higher Studies.* Preliminary report.

Effective mentoring is one of the most important key factors for student engagement, retention, and motivation for higher studies. Quantity and quality of faculty-student interactions outside classroom particularly in a minority serving institutions plays a significant role in students' retention. Many minority students are first in their families to attend colleges and academically under-prepared for the college studies. Lack of financial aid in the form of scholarships or grants also make it harder for minority students to pursue higher studies. Recently however, an effort is made to increase financial aid, in particularly for undergraduate education. Close interactions with the mentors provide students from diverse backgrounds a sense of belongings and make them feel welcome in the institution. In this presentation numerous bio-math connected classroom and research problems will be discussed and students' reflections will be shared. (Received September 22, 2010)

Using Program Assessment to Improve Student Learning

1067-Y1-1567 **Sarah V Cook*** (sarah.cook@washburn.edu), 1700 SW College Ave, Topeka, KS 66621, and **Donna LaLonde** (donna.lalonde@washburn.edu), 1700 SW College Ave, Topeka, KS 66621. *Assessment: What are we learning?* Preliminary report.

The focus of assessment at Washburn University is to be able to answer three fundamental questions: What do we want our students to know? How do we know they are learning it? What do we do if they aren't? Over the last several years the Mathematics and Statistics Department has worked to implement an assessment plan that provides meaningful answers to these questions. In this presentation, we will highlight our successes, struggles, and future endeavors. (Received September 21, 2010)

1067-Y1-1653 **Jacalyn M Huband*** (jhuband@uwf.edu), Jacalyn M. Huband, 1350 N. Poquito Road, Shalimar, FL 32579-1163. *Constructing Tests for Program Assessment.* Preliminary report.

A trend in higher education is program assessment (i.e., determining if the students graduating from our program have the knowledge that we, as an institution, are claiming they have). Usually, program outcomes are mapped to learning outcomes of the courses, which then are assessed through coursework. Often, there are disconnects between the statement of program outcomes and the materials collected to assess the outcomes. In this presentation, I will describe an approach to design tests for data collection in a mathematics course for engineers and will discuss the results of implementing the approach. (Received September 21, 2010)

1067-Y1-1670 **Joe A. Guthrie** (jguthrie@utep.edu), Department of Mathematical Sciences, UTEP, El Paso, TX 79968, and **Helmut Knaust*** (hknaust@utep.edu), Department of Mathematical Sciences, UTEP, El Paso, TX 79968. *Course-based Program Assessment.*

The Department of Mathematical Sciences at the University of Texas at El Paso has implemented a program assessment plan based on the evaluation of seven courses central to our undergraduate programs. We will give an overview of the history of the assessment plan, discuss the design of the assessment strategies, and report on the changes both to the assessment and to the affected courses resulting from the assessment efforts. The presentation will conclude with a discussion of the challenges encountered. (Received September 21, 2010)

1067-Y1-1911 **jenn d berg*** (jberg5@fitchburgstate.edu), Fitchburg State University, Department of Mathematics, 160 Pearl Street, Fitchburg, MA 01420. *Using Rubrics for Calculus 2 Maple Labs.*

The author used two types of rubrics for Maple labs assigned to students in a Calculus 2 course: one tied to department level (program level) assessment goals, and one tied to the specific content covered in the lab. We will look at how these two different types of rubrics affected student learning in two ways: We will look at the data collected over the term, charting student progress, we will also look at students responses to a survey on how they felt the availability of the rubrics helped them learn the material. (Received September 22, 2010)

1067-Y1-1913 **Vonda K Walsh*** (walshvk@vmi.edu), Virginia Military Institute, 435 Mallory Hall, Lexington, VA 24450. *Improving Student Proficiency in Statistics through Core Curriculum Assessment at Virginia Military Institute.* Preliminary report.

Often in statistics service courses, the instructor is faced with negative attitudes toward statistics, low motivation and statistical knowledge that is marginal and not transferable. In this talk I will discuss what I, in my role as statistical coordinator, used to evaluate and improve the quality and uniformity of instruction and quality of student learning in statistic courses that were taken as a part of the VMI core curriculum. (Received September 22, 2010)

1067-Y1-2174 **Lee A Evans*** (lee.evans@usma.edu), D/Math, Thayer Hall, West Point, NY 10996, **Jeremy M Riehl** (Jeremy.Riehl@usma.edu), D/Math, Thayer Hall, West Point, NY 10996, and **Kristin M Arney** (kristin.arney@usma.edu), D/Math, Thayer Hall, West Point, NY 10996. *Assessing and Improving Students' Fundamental Mathematical Skills throughout their STEM Education.* Preliminary report.

Students enter the STEM programs with different backgrounds in mathematics. Our experience indicates that if students lack a good understanding of 13 fundamental pre-calculus skills and concepts that we have identified, they will most likely not perform to their full potential in subsequent math, science, and engineering courses. We have developed a method for assessing and improving students' fundamental skills throughout the core mathematics sequence and into STEM disciplines. In this session, we will discuss ways to strengthen students' mathematical fundamentals, our assessment techniques, and how we collaborate with other STEM disciplines on motivating and improving proficiency in the needed areas. (Received September 22, 2010)

Wavelets In Undergraduate Education

1067-Y5-981 **Tanya Leise*** (tleise@amherst.edu), Department of Mathematics, Amherst College, Amherst, MA 01002. *Undergraduate research in wavelets and circadian rhythms.* Preliminary report.

Circadian rhythms are the roughly 24h patterns observed in both locomotor activity and gene expression in a wide variety of organisms. These rhythms can be entrained to the daily light-dark cycle but also persist in the absence of time cues, for example, in constant very dim light. Wavelet ridge analysis using complex-valued analytic wavelets has emerged as an effective tool to measure period, phase, and amplitude over time in noisy, non-stationary circadian time series. I supervised a group of math majors from Amherst College who worked with biology majors at Smith College to apply wavelet ridge analysis to wheel running records and clock gene expression data as part of a project to study the central circadian clock in the brain as well as peripheral clocks found in tissues throughout the body. (Received September 17, 2010)

1067-Y5-1269 **Bruce W. Atkinson*** (bwatkins@samford.edu), Dept. of Math/CS, Samford University, 800 Lakeshore Dr., Birmingham, AL 35229. *An Undergraduate Research Project on Multiwavelets.* Preliminary report.

Construction of the traditional Haar wavelets begins with the Multiresolution Analysis (MRA) V^n, for $n \in \mathbb{Z}$, where V^n consists of square integrable functions that are constant on intervals formed by consecutive multiples of $1/2^n$. An orthonormal basis for V^0 consists of the function $\phi = \chi_{[0,1)}$ and all of its integer translates. An orthonormal basis for the wavelet space $W^0 = V^1 \ominus V^0$ consists of a single wavelet ψ and all of its integer translates.

For this project fix integer $j > 0$ and consider the MRA V^n consisting of square integrable functions that are constant on intervals formed by consecutive multiples of $1/j^n$. An orthonormal basis for V^0 still consists of the function ϕ and all of its integer translates. However, an orthonormal basis for the wavelet space $W^0 = V^1 \ominus V^0$ now consists of a set of $j-1$ functions and their integer translates. The construction of the $j-1$ multiwavelets uses a modified version of the Gram-Schmidt process. Applications of these multiwavelets will be given. (Received September 20, 2010)

1067-Y5-1539 **Kevin F. Palmowski*** (kfp1@geneseo.edu), Box 3881, 10 MacVittie Circle, Geneseo, NY 14454. *Who Are You? An Image Identification Project Using Wavelet Packet Analysis.*

In the last fifty years, face recognition has become one of the most active research areas in pattern identification. It plays an integral role in various applications, including human-computer interaction, authentication, and surveillance. However, large variations in the human face caused by pose, illumination, facial hair, and expression make this problem very complex. The ability of wavelets to capture the spatial and frequency information of an image make them ideal for feature extraction. We will present the modification of a face-based algorithm proposed by C. Garcia, G. Zikos, and G. Tziritas that uses statistical analysis on a level-two wavelet packet decomposition as its classifying criterion. The algorithm, coded using MATLAB, successfully identified each of 25 sample images. (Received September 21, 2010)

1067-Y5-1561 **Bruce Atwood*** (atwoodb@beloit.edu), 700 College St., Box 224, Beloit College, Beloit, WI 53511, and **Kevin Braun** and **Tess Jacquez**. *Denoising Capillary Electrophoresis Signals with Wavelets.* Preliminary report.

Denoising experimental data provides a unique platform to develop collaborative undergraduate research projects between math departments and other disciplines. We describe one such collaboration between the Chemistry and Math departments at Beloit College in the application of wavelets to denoise analytical signals.

Capillary electrophoresis is one of the most widely utilized separation techniques for low-volume, high-speed, and high-sensitivity separation and real-time analysis of biologically active compounds. Methods to improve the sensitivity of capillary electrophoresis such as linear array signal averaging and Hadamard transform are often associated with a temporal resolution reduction, thus of limited use for the real-time analysis of fast biological processes. Wavelets provide an efficient post-collection denoising strategy that yields improved sensitivity while not affecting the temporal resolution. To optimize the application of wavelets in denoising electropherograms, the effect of wavelet type and threshold functions on peak shape and area has been explored. (Received September 21, 2010)

1067-Y5-1606 **Joseph M Gonzalez*** (jmgonza6@mail.usf.edu), 4122 Causeway Vista Dr., Tampa, FL 33615, **Brian K Holder-Chow Lin On** (brianh@mail.usf.edu), 5109 Excellence Blvd., 515A, Tampa, FL 33617, **Robert Le** (rle@mail.usf.edu), 11922 69th Way North, Largo, FL 33773, and **Michael Anthony Miller** (mmille11@mail.usf.edu), 10811 Fairfield Village Drive, Tampa, FL 33624. *Efficiently Programming RGB-to-HSI Conversion.*

In the world of digital image processing, there are various ways of representing color images. These include RGB (Red, Green, Blue), HSI (Hue, Saturation, Intensity), and other color spaces such as CMYK (Cyan, Magenta, Yellow, Black). The RGB space is an efficient method for capturing digital images but has deficiencies. For example, if one wants to change the brightness of an RGB pixel, one must adjust values in all three matrices (R, G, B), whereas in the HSI representation, this same operation requires a single value change. The HSI color space is a representational model which closely mimics the representation of imagery found in the human brain, therefore it is a reasonable manner in which to represent image data which must be processed. The goal of this talk is to describe an efficient algorithm for converting images from RGB to HSI space and back. Such conversions are used for example in analyzing multi-spectral & panchromatic satellite images. (Received September 21, 2010)

1067-Y5-1611 **Patrick J Van Fleet*** (pjvanfleet@stthomas.edu), 2115 Summit Avenue #OSS201, Department of Mathematics, University of St. Thomas, St. Paul, MN 55105. *Wavelets and Lifting.* Preliminary report.

The discrete wavelet transformation is an important tool in applications involving signal processing. Applied to a signal of length N, the discrete wavelet transform returns a length $N/2$ lowpass response and a length $N/2$ highpass response. Due to the sparse nature of the matrix representation of this transformation, fast algorithms exist for its implementation.

A highly efficient way to implement the transformation is through *lifting*. This algorithm, due largely to Wim Sweldens, begins by computing the highpass response and then *lifts* the lowpass response from part of the original data and the highpass response.

For particular lowpass/highpass filter pairs used to construct the transformation, it is straightforward for students to derive the lifting algorithm. For those other cases, Sweldens provides a theorem that describes how the algorithm can be constructed. This derivation requires some knowledge of Fourier series and the Euclidean algorithm. We have found that the implementation of Sweldens' result for some filter pairs leads to a interesting undergraduate project.

In this talk, we will outline the algorithm and describe how it can be formulated as a project for students who have some background in Fourier series and wavelets. (Received September 21, 2010)

1067-Y5-1752 **Edward F Aboufadel*** (aboufade@gvus.edu), Dept. of Mathematics, A-2-178 MAK, Allendale, MI 49401. *Using Wavelets and Statistics to Detect Differences.* Preliminary report.

In this talk, we will describe what undergraduate students can learn from applying statistics to wavelet coefficients, and why this statistical approach has been used the past decade to study imitations of famous artists, forgeries of handwriting, and time series data from biology. The main idea is that wavelet filters can be used to detect subtle differences. (Received September 21, 2010)

1067-Y5-1753 **Veronika Furst*** (furst_v@fortlewis.edu), Fort Lewis College, Department of Mathematics, 1000 Rim Drive, Durango, CO 81301. *Teaching operator theory to undergraduates via frames.* Preliminary report.

During the summer of 2010, I had the opportunity to teach a two-week minicourse entitled "Operator Theory Via Finite Frames," as part of The George Washington University Summer Program for Women in Mathematics. Every one of the sixteen students had had a course in linear algebra, some had seen real analysis while others had taken abstract algebra. With this background, I was able to present sophisticated notions in finite-dimesional operator theory, using finite frames as a motivation throughout. In this talk, I will give a brief introduction to the theory of frames and explain the rationale behind using this topic as an ideal foundation for a minicourse, a project within a course, or a semester-long topics course to follow linear algebra. I will point out references for undergraduate-accessible course material as well as possible projects. Natural extensions into infinite-dimensional spaces, infinite frames, and Parseval wavelets will be briefly discussed. (Received September 21, 2010)

1067-Y5-1826 **Helmut Knaust*** (hknaust@utep.edu), Department of Mathematical Sciences, UTEP, El Paso, TX 79968. *Lloyd-Max Quantization Schemes.*

Quantization is used in image processing to achieve lossy compression by reducing the range of values occurring in a signal. Quantization is an integral part of both the JPEG and JPEG2000 standards. Lloyd-Max quantization algorithms in particular are designed to minimize the mean square error (or another suitable target function) during the quantization process. We will give a short introduction to Lloyd-Max quantization and its implementation in image processing. This open-ended topic is suitable for student projects in an undergraduate wavelets, signal processing, modeling, or applied probability course. (Received September 21, 2010)

1067-Y5-1829 **John Merkel*** (jmerkel@oglethorpe.edu), Oglethorpe University, 4484 Peachtree Road NE, Atlanta, GA 30319, and **Patrick Van Fleet** and **David Ruch**. *Undergraduate Research Projects on Pansharpening.* Preliminary report.

In this talk we present ideas for undergraduate research projects based on pansharpening techniques utilizing discrete wavelets. Pansharpening is the process of merging a high resolution panchromatic (black/white) image with a lower resolution multispectral (color) image to create a high resolution color image. Pansharpening is often applied to satellite images, which typically exist in these high/low resolution pairs. (Received September 21, 2010)

1067-Y5-1901 **Cristen Bonz*** (cmbonz@stthomas.edu), 1897 St Clair Ave #2, Saint Paul, MN 55105, **Elizabeth Motz** (eamotz@stthomas.edu), University of St Thomas, Mail 0296, 2115 Summit Ave, Saint Paul, MN 55105, and **Susan Ray** (slray@stthomas.edu), 2111 Selby Ave Apt #1, Saint Paul, MN 55105. *Multiwavelets and Image Compression.*

Image compression allows for a decrease in the amount of necessary storage space from the usual 8 bits per pixel. In this project, a multiwavelet packet transformation is used as part of a compression routine for a class of homogeneous images. Specifically, we work with satellite images. These files are extremely large and consist of several channels. We will describe the compression algorithm and in particular, the significant role spectral density analysis plays in developing an optimal multiwavelet packet transformation. Examples of the algorithm will be included throughout the presentation. (Received September 22, 2010)

1067-Y5-1925 **Rachel J Weir*** (rweir@allegheny.edu), Department of Mathematics, Allegheny College, Meadville, PA 16335. *Introducing Wavelets to First Years and Sophomores.*

Using Patrick Van Fleet's book *Discrete Wavelet Transformations: An Elementary Approach with Applications* as a guide, I have included elementary wavelet theory in both a first year seminar and a Linear Algebra class. The seminar assumes no prior mathematical background beyond high school algebra and I will discuss how I present wavelet theory in this setting, including a summary of the successes and challenges. (Received September 22, 2010)

1067-Y5-2085 **Jeff Knisley*** (knisleyj@etsu.edu), Box 70663, Department of Mathematics, East Tennessee State University, Johnson City, TN 3714-0663. *Exploring Biomedical Signals with the Maple Wavelets Package.*

Students tend to be familiar with ElectroCardiograms (Ekg's) and ElectroEncephalograms (EEG's) from popular culture, and there is a wealth of such data freely available. Less familiar but also readily available are signals related to circadian rhythms and other applications in biology and ecology. Moreover, questions about Ekg's, EEG's, and other biological/biomedical phenomena often focus on time and scale, making wavelet-based approaches especially attractive. As we will show in this presentation, many of these signals are amenable to investigation with the wavelets package in Maple, thus making such applications especially suitable as undergraduate research opportunities for students already familiar with Maple from previous courses. (Received September 22, 2010)

General Session

1067-Z1-17 **Linda Furuto*** (lfuruto@hawaii.edu), 96-129 Ala Ike, C104E, Pearl City, HI 96782. *Bridging Policy and Practice with Ethnomathematics.*

In an effort to bridge policy and practice in diverse populations, this presentation focuses on research conducted at U.S. higher educational institutions (Harvard University, UCLA, and the University of Hawaii) in the field of ethnomathematics. Ethnomathematics is the study of the relationship between mathematics and culture, including ethnicity, socioeconomic class, special needs, and English language learners. As an example of ethnomathematics, the University of Hawaii – West Oahu opened its first Mathematics Center with a National Science Foundation grant last year. The Hokule'a, "star of gladness," is a voyaging canoe that is an integral part of the center and connects students to cultural and historical traditions. The Hokule'a is internationally renowned for the role it has played in rekindling the Polynesian tradition of celestial math navigation to locations such as Tahiti, Rapa Nui, Marquesas, Samoa, Micronesia, Japan, and the U.S. mainland, and is preparing for a voyage around the world in 2013, which the lead presenter will be participating in. It is a vehicle to explore real-world applications of mathematics in the Hawaiian and global communities, and represents resourcefulness, inventiveness, wisdom grounded in the past, and hope for the future. (Received May 06, 2010)

1067-Z1-23 **Rodrigo Ristow Montes*** (ristow@ufpr.br), Departamento de Matemática - UFPR, Setor de Ciencias Exatas - Centro Politecnico, Jardim das Americas, Curitiba, Brazil 81531-990, Brazil. *Contact angle for minimal surfaces in the sphere S^5.*

We provide a congruence theorem for minimal surfaces in S^5 with constant contact angle using Gauss-Codazzi-Ricci equations. More precisely, we prove that Gauss-Codazzi-Ricci equations for minimal surfaces in S^5 with constant contact angle satisfy an equation for the Laplacian of the holomorphic angle. Also, we will give a characterization of flat minimal surfaces in S^5 with constant contact angle. (Received May 24, 2010)

1067-Z1-25 **Sunil Mathur*** (skmathur@olemiss.edu), Hume 325, Department of Mathematics, University of Mississippi, University, MS 38677. *A Generalized Slope Based Scale-Invariant One Sample Nonparametric Test For Bivariate Location Problem.*

A generalized test is proposed for bivariate one sample location problem. The proposed test is based on the slopes obtained by using two variates. The asymptotic distribution of the proposed test statistic is found. The proposed test statistic does not depend on the covariance structure of the population, and is scale-invariant. The proposed test statistic is compared with several test statistics using Monte Carlo technique. For non-normal distributions, the proposed test statistic performs better than most of the test statistics under consideration, some of which are based on two-samples, for almost all the shifts in the location. Application of the test is also illustrated using a bivariate data set. (Received May 28, 2010)

1067-Z1-45 **Jim Gleason*** (jgleason@as.ua.edu), Department of Mathematics, Box 870350, The University of Alabama, Tuscaloosa, AL 35487-0350, **Daniel Burton**, Department of Mathematics, Box 870350, The University of Alabama, Tuscaloosa, AL 35487-0350, and **Martin Bakker**, Department of Chemistry, Box 870336, The University of Alabama, Tuscaloosa, AL 35487-0336. *Using Online Mathematics Modules for Physical Chemistry Students.* Preliminary report.

Among chemistry majors, the physical chemistry course is one of the most challenging as determined by grades and pass rates. Much of this difficulty is likely due to the amount and difficulty of the mathematics required for the course. While the prerequisites for physical chemistry courses are usually two semesters of calculus, they often use differential equations, partial derivatives, triple integrals, and linear operators on infinite dimensional vector spaces. In a partnership between the Departments of Chemistry and Mathematics, a series of online modules have been developed to help the physical chemistry students to review the mathematics from the first two semesters of calculus, and to help teach the mathematics as needed throughout the remainder of the semester. In this presentation, we will discuss the successes and difficulties in creating and implementing these modules as well as plans for future research and broader implementation. (Received June 16, 2010)

1067-Z1-46 **Jay L. Schiffman*** (schiffman@rowan.edu), 201 Mullica Hill Road, Glassboro, NJ 08028-1701. *Some Prime Curiosities.* Preliminary report.

From the advent of the ancient Greek civilization, the prime numbers have served as a conversation piece among both professional and novice mathematicians. In this paper, I will focus on ideas concerning some selected prime numbers not currently in Chris Caldwell's Prime Curios (as of June 21, 2010)taken from his Prime Pages and furnish evidence as to why they are novel and should be included. Among our examples, we include first primes involving prime quadruples, Euclid numbers, fibonorials or Fibonacci factorials, factorial primes, and other variations on Euclid [n] where Euclid [n] is the product of the first n primes plus 1. Please join us to discover enhanced insights involving the atoms of our natural number system. (Received June 21, 2010)

1067-Z1-61 **Shari S Levine*** (Shari.Levine@seh.ox.ac.uk), St. Edmund Hall, Queens Lane, Oxford, OX1 4AR, England. *Cleavability over Fréchet-Urysohn LOTS.*

In this talk we will show that if X is a compact T_2 space cleavable over a Fréchet-Urysohn linearly ordered topological space (LOTS) Y, then X does not have to be homeomorphic to a subspace of Y. We will then discover the conditions under which cleavability implies a homeomorphism exists. Furthermore, we will show that if X is a compactum cleavable over a Fréchet-Urysohn LOTS, then X is a LOTS. (Received July 07, 2010)

1067-Z1-69 **G. Joseph Wimbish*** (jwimbish@cfl.rr.com). *Palindromic Curiosities.* Preliminary report.

Palindromes are usually defined as sequences of symbols that read the same way left to right as right to left. For example, radar, 313, mom, MADAM I'M ADAM. Sometimes, but not always one can produce a palindrome in unexpected ways. For example, choose a five digit number at random, such as 56892 reverse the digits to get 29865, subtract the smaller from the larger to get 27027. Divide this result by 9 and obtain 3003 which is a 4th order numeric palindrome. A counter example is 53894. We seek to answer the following questions. First: Why when one chooses a number at random, reverses the digits and subtracts the two numbers one always gets a number divisible by 9? Second: why should one ever get a palindrome? Third: We will prove that any even order numeric palindrome is divisible 11 and examine the issue of odd order numeric palindromes. (Received July 07, 2010)

1067-Z1-89 **Jeffrey W Clark*** (clarkj@elon.edu), Campus Box 2320, Elon University, Elon, NC 27244. *Mentoring Undergraduate Research for All Mathematics Majors.*

At most colleges and universities with a full teaching load (three or four classes per term), it is difficult to mentor undergraduate research in mathematics. This presentation will discuss lessons learned from over twenty years of mentoring mathematics majors. A student's research topic is not nearly as important as cultivating a rapport with the student before beginning and setting out clear and achievable goals for both student and mentor. Ideally all students are capable of performing research at a level that is appropriate to their abilities. (Received July 22, 2010)

1067-Z1-194 **Murray H Siegel*** (murray.siegel@asu.edu), ASU - Applied Sciences & Mathematics, 6073 S Backus Mall, Mesa, AZ 85212. *Using a data modeling project to enhance the teaching of the derivative.*

Students in a one-semester Brief Calculus course explore using algebraic functions to model real world data. After investigating the derivative, students complete a project in which the student selects a set of bivariate data of interest to him/her. For the data set, five models are determined. After evaluating each of the models, the student selects the three best models for further investigation. For each model, the derivative and second derivative are computed. Extrema and inflection points are identified. The student selects the best model and justifies that choice. Finally, the student must explain why the conclusions based on calculus (increasing, decreasing, minima, maxima, inflection points) make sense based on the student's knowledge of the data. A written report is submitted which represents twenty percent of the semester grade. (Received July 30, 2010)

1067-Z1-229 **Mohammad K. Azarian*** (azarian@evansville.edu), University of Evansville, Department of Mathematics, 1800 Lincoln Ave., Evansville, IN 47722. *A Differential Equation Wtih Many Faces.*

In this presentation we solve a class of first-order ordinary differential equation where its general solution encompasses the six most common methods of solving a first-order ordinary differential equation. We conclude our discussion by posing two questions. (Received August 10, 2010)

1067-Z1-292 **Robert L Brabenec*** (robert.brabenec@wheaton.edu), Department of Mathematics, Wheaton College, 501 College Ave, Wheaton, IL 60187. *The "More" Method of Teaching Proofs.*

The Moore methodI replaces the traditional lecture method by the opposite extreme of student presentation of proofs of theorems from a list provided by the teacher. The main claim for effectiveness of Moore's method is that it enables students to learn how to prove theorems independent of help from any source, and to express these proofs orally. Liabilities of the method include complete avoidance of written literature and dialogue with classmates. Also the scenario of proof after proof needs interruption by enrichment insights from the teacher's experience. The word 'more' refers to desirable items I feel are missing from the Moore method. In the fall of 2010, I will use the following approach with 18 real analysis students. Each day a sheet of questions to investigate will be given. The next class will begin with student responses to these questions. Students are to first try these questions on their own before consulting a text or another student. The class will be divided into 3 groups, each meeting weekly to respond to questions over material from the previous week. Instead of the teacher being a silent observer in the classroom, this method proposes active interchange of ideas among faculty and students in each class session. My talk will present results of this approach. (Received August 16, 2010)

1067-Z1-319 **E. Lee May, Jr.*** (elmay@salisbury.edu), MATH/COSC, 1101 Camden Avenue, Salisbury, MD 21801. *The Quill Chart: Sensitizing Faculty to End-of-Term Stresses.*

During the 1980's, two of my colleagues and I discovered that, toward the end of each semester, we acted like porcupines. Specifically, we found ourselves to be less tolerant of the behavior of students. We became particularly irritated by those who came to us in the midst of death-bed conversions regarding their motivation toward their courses. To sensitize ourselves to the arrival of this part of the semester and our behavior during it, we devised the Quill Chart, along with the Quill Competition that it supported. The chart proved effective in ameliorating the exam-time behavior (if not the attitudes) of its three originators. In addition, as word of the Quill Chart spread within the Salisbury University Department of Mathematics and Computer Science, others asked to be included in the competition. The talk is a summary of the Quill Chart and Competition. It includes not only more detail on their history but also the rules of the competition; some remarks about its effectiveness; and some tips for avoiding quills. The talk is offered in the belief that other academic departments face end-of-the-term challenges similar to that of the SU faculty, and therefore would benefit from learning about the Quill Chart. (Received August 20, 2010)

1067-Z1-327 **Paul Raymond Bouthellier*** (pbouthe@pitt.edu), 504 East Main Street, Titusville, PA 16354. *Video Game Design=Mathematics.*

In this talk we shall give an overview as to how concepts from mathematics and physics are used to create the computer graphics and programs which are used in movies, television, computer games, medical imaging and many other fields. Images and movies generated in programs such as Flash, Poser, Swift3D, Studio 3D Max, Maya, and Carrara will be used to illustrate: Bezier curves and NURBs for modeling, 2 and 3 dimensional mappings (UV and UVW mappings) for creating textures, quaternions and matrices for scaling, translations, skewing, and rotations, and cross and dot-products for back-face culling. (Received August 23, 2010)

1067-Z1-336 **Lan Cheng*** (lan.cheng@fredonia.edu), Department of Mathematical Science, SUNY Fredonia, Fredonia, NY 14063, and **Xuguang Sheng**, Washington, DC 20016. *Combinations of "combinations of p-values".*

In this paper we investigate the impact of uncertainty over the number of false null hypotheses on commonly used p-value combination methods. Some methods,for example,Tippett's and Simes' methods, are powerful when there is only one or a few false individual null hypotheses. Others such as Fisher's and Stouffer's methods are powerful when there are many false null hypotheses. Since it is a priori unknown whether a few or almost all individual null hypotheses are false, no uniformly most powerful p-value combination method exists. We develop a combination of "combinations of p-values"(CCP) test that maintains good power properties in the presence of such an uncertainty, while at the same time controls type I error. Our test is based on a simple union of rejections decision rule, whereas the joint null hypothesis is rejected at the significance level α if at least one of the two p-value combination methods yields a rejection at the level γ. The value of γ depends on the significance level, sample size and the correlation of two p-value combination methods. Our results show that Tippett's and Simes' methods are almost perfectly orrelated, Fisher's and Stouffer' highly correlated, and Simes'(Tippett's)and Fisher's (Stouffer's) almost uncorrelated. (Received August 24, 2010)

1067-Z1-401 **Ken M Collins*** (kcollins@charlottelatin.org), 2024 Bucknell Ave, Charlotte, NC 28207. *Explorations that enhance student understanding of limits and derivatives.*

This session will share several investigations we have used in the classroom to help strengthen our students' understanding of limits and derivatives. We will discuss some ideas for developing these investigations and offer reproducible copies to use in your classes. All levels of teaching experience are welcome. (Received September 01, 2010)

1067-Z1-402 **Raymond N. Greenwell*** (matrng@hofstra.edu), Department of Mathematics, Hofstra University, Hempstead, NY 11549, and **Nathan P. Ritchey** (npritchey@ysu.edu), Department of Mathematics, Youngstown State University, Youngstown, OH 44555. *Using Wolfram|Alpha in finite mathematics and applied calculus.* Preliminary report.

Wolfram|Alpha is a powerful web-based tool available free to anyone with a browser and internet access. We will show examples of how it might be used in a finite mathematics and a calculus class. In particular, we will look at uses in regression, matrix arithmetic, linear programming, solving equations, graphing function of one or more variables, integration, and differential equations. (Received September 01, 2010)

1067-Z1-443 **Jinglong Ye*** (jy79@msstate.edu), 27 O Wallace Circle, Starkville, MS 39759, and **EunKyoung Lee** and **Ratnasingham Shivaji**. *Positive Solutions for Infinite Semipositone Problems with Falling Zeros.*

We consider the positive solutions to the singular problem

$$\begin{cases} -\Delta u = au - f(u) - \frac{c}{u^\alpha} & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega \end{cases} \tag{P}$$

where $0 < \alpha < 1$, $a > 0$ and $c > 0$ are constants, Ω is a bounded domain with smooth boundary and $f : [0, \infty) \to \mathbb{R}$ is a continuous function. We assume that there exist $M > 0$, $A > 0$, $p > 1$ such that $au - M \leq f(u) \leq Au^p$, for all $u \in [0, \infty)$. A simple example of f satisfying these assumptions is $f(u) = u^p$ for any $p > 1$. We use the method of sub-supersolutions to prove the existence of a positive solution of (P) when $a > \frac{2\lambda_1}{1+\alpha}$ and c is small. Here λ_1 is the first eigenvalue of operator $-\Delta$ with Dirichlet boundary conditions. We also extend our result to classes of infinite semipositone systems. (Received September 13, 2010)

1067-Z1-444 **Chris Christensen*** (christensen@nku.edu), Department of Mathematics and Statistics, Northern Kentucky University, Highland Heights, KY 41099. *Revisiting Lester Hill.*

Throughout his mathematical life Lester Hill was interested in topics that we would now think of as cryptology. Prior to his 1929 and 1931 papers in which matrix encryption was introduced, Hill was interested in authentication, and in the 1950s he wrote papers on cryptology which he sent to Naval Communications. We will briefly survey Hill's work. (Received September 03, 2010)

1067-Z1-464 **Noureen A. Khan*** (noureen.khan@unt.edu), University of North Texas Dallas, 7300 Houston School Road, Dallas, TX 75241, and **Ramanjit Sahi** and **S N Jator**. *Second derivative Adams-type methods for boundary value problems.*

"We develop and apply second derivative Adams-type methods (SDAMs) for solving linear and non linear boundary value problems. We show that this method is convergent of the order 2k + 2 (k is the step number). Numerical examples illustrate the efficiency of the method over existing methods." (Received September 05, 2010)

1067-Z1-480 **Patricia Baggett*** (baggett@nmsu.edu), Dept of Math Sci, MSC 3MB PO Box 30001, New Mexico State University, Las Cruces, NM 88003-8001, and **Andrzej Ehrenfeucht** (andrzej.ehrenfeucht@colorado.edu), Computer Science Dept., PO Box 430, University of Colorado, Boulder, CO 80301-0430. *Counting.*

Counting a large number of items is hard. People and animals are moving. Objects are spatially dispersed. Events are spread over time. So usually one counts small numbers of items at one time, creates a written or electronic record, and finally sums the numbers. This was not always the case. In pre-literate societies in the Middle East (e. g. Sumerian), records were kept by creating tokens that represented real items. Of course counting tokens is much easier than counting the real things. But independent of its practical value, counting a large numbers of small objects (such as the number of beans in a one pound bag) can be a valid task for young children in early elementary grades, because many of them are fascinated by large numbers. We don't know how counting was done in the distant past, but we can theoretically evaluate the feasibility of different algorithms. We describe an algorithm of "counting by partitions", in which most of the work can be done by someone with no mathematical knowledge. We analyze its feasibility from the point of view of the "human resources" that are needed to make it practical, and we compare it to counting algorithms taught in American schools. We conclude that "counting by partitions" is practically feasible, but "school algorithms" are not. (Received September 06, 2010)

1067-Z1-482 **Ezra A. Brown*** (ezbrown@math.vt.edu), Mathematics Department, Virginia Tech, Blacksburg, VA 24061-0123. *Interpolation and remainders: two formulas that are really the same.*

To pass a polynomial through a set of points, use the Lagrange Interpolation formula. To construct an integer satisfying a set of congruences, use the Chinese Remainder Theorem. This talk is about how these two classic results are really the same, and how the speaker came to realize this while teaching two back-to-back classes. (Received September 06, 2010)

1067-Z1-503 **William W Miles*** (wmiles@stetson.edu), Unit 8332, DeLand, FL 32723, and **Lisa O Coulter** and **Gary Fowks**. *ACCUV COLLEGE FOOTBALL RANKING MODEL.*

This work extends the work of Coleman which provides a football rankings system that minimizes game score violations. The modified model, called *AccuV*, developed in this paper incorporates several other aspects of most rankings systems including: strength of schedule, margin of victory, and home field advantage. These other components of a team's rank are included via an additional variable called the composite index. In addition to these new components, other bounding constraints have been added. These new constraints significantly reduce the solve-time of the model. The model of Coleman achieved a minimum of 55 game score violations for the complete 2002 season in about 36 seconds with 234,313 iterations as reported by LINGO. However, with the addition of the new constraints, the new model (without the additional ranking components) established the same minimum in only 6 seconds with a total of 55,119 iterations. This work is also easily extendable to allow the addition of other components if desired. (Received September 07, 2010)

1067-Z1-519 **Jason M Osborne*** (jason.osborne@olin.edu), Olin Way, Needham, MA 12492-1200. *A Geodesic- And Parallel-Transport Based, Mass-Spring-Damper Error System On The Euclidean Sphere.*

Using the intrinsic differential geometry of the Euclidean sphere $\mathbb{S}^2$, a control design based on the geodesic–spring paradigm for tracking on $\mathbb{S}^2$ is realized and simulated. At the heart of this design is (1) a generalized Hookean potential whose differential is a force vector with strength and direction defined in terms of the great circles (geodesics) on the sphere $\mathbb{S}^2$, and (2) a generalized damping force defined in terms of parallel transport along the great circles. The geodesic spring design is not original to this work. In general, this control design requires the solution to the geodesic equation as a two–point boundary value problem and the solution to the parallel transport equation as an initial value problem. However, by focusing on $\mathbb{S}^2$, a closed-form expression of the generalized Hookean potential and damping force is obtained and numerical simulations performed. In special cases, closed form solutions to the resulting closed loop equations are also exhibited. (Received September 08, 2010)

1067-Z1-530 **Dale K Hathaway*** (hathaway@olivet.edu), Olivet Nazarene University, Department of Mathematics, One Unviersity Avenue, Bourbonnais, IL 60914, and **Mark J Lockwood** (mlockwo1@live.olivet.edu), Olivet Nazarene University, ONU box 7579, One University Avenue, Bourbonnais, IL 60914. *Probabilistic Pentominos and other Polyforms.*

Typically polyforms are examined a size at a time as with pentominos. But what if they are constructed recursively by starting with a square and attaching another square to one of the edges of the initial square where the

location of the new square was determined probabilistically. Continuing this process we can construct polyforms of any size. This process associates a probability with each figure. Relationships between the probabilities and the figures will be examined. This idea will also be extended to figures that start with equilateral triangles, hexagons, and even cubes in three dimensions. This talk is based on the work done in a summer research experience by the second author under the direction of the first author. (Received September 08, 2010)

1067-Z1-535 **Christopher M Kuster*** (ckuster@carrollu.edu), Carroll University, Department of Mathematics, 100 N East Ave, Waukesha, WI 53186, and **John C Symms** (jsymms@carrollu.edu), Carroll University, Department of Mathematics, 100 N East Ave, Waukesha, WI 53186. *An Introductory Computational Thinking Sequence for Science Majors.* Preliminary report.

This year, Carroll University is piloting a two-course introductory computational thinking sequence for students in bachelor of science degree programs. This sequence will eventually be proposed to be part of the general B.S. degree requirements at the University. The first course covers general computation techniques, mathematical modeling, algorithmic thinking, and data analysis. We will discuss course design as well as teaching experiences and measures of student learning. (Received September 08, 2010)

1067-Z1-561 **Denise J LeGrand*** (djlegrand@ualr.edu), 303 N Park St, Little Rock, AR 72205. *Integrating Technology to Match Learning Styles in an Online Mathematics Course.* Preliminary report.

It is well known that people learn in a variety of ways. The importance of this knowledge for us as teachers is the realization that 1) we need different teaching styles and that 2) we can help our students become aware of their own style. This awareness can help students focus in on how they learn best and if a variety of tools are offered, the chances of successful learning and communication drastically increase. There are many learning style surveys available and no matter which one is used we can incorporate the appropriate technology into our classes that matches each style. This is not about accommodation but about teaching and learning strategies. I will explain 4 learning styles, match each with available technology and then show how I use some of these the technological resources in teaching online Calculus. Most of the technology is free via the web and is not a stranger to students growing up in the digital age. Some examples are communication tools such as Discussion Boards and Blogs, organizational tools such as Blackboard, multimedia such as videos, and various instructional sites. These can all be blended seamlessly into a successful mathematics course that includes community building and matches available technology to each learning style. (Received September 09, 2010)

1067-Z1-565 **Iwan Praton*** (iwan.praton@fandm.edu), Department of Mathematics, Franklin and Marshall College, Lancaster, PA 17604. *Tiling a square with squares.* Preliminary report.

Pack a unit square with n squares of side lengths $s_1, \ldots, s_n$. Define $\phi(n) = \max \sum s_i$, where the maximum is taken over all packings of the unit square where the sides of the small squares are parallel to the sides of the unit square. Define also $\psi(n) = \max \sum s_i$, where the maximum is taken over all tilings of the unit square. (A tiling is a packing with no space left empty.) Clearly $\phi(n) \geq \psi(n)$. Staton and Tyler asked for what values of n we have $\phi(n) = \psi(n)$. We show that $\phi(8) \neq \psi(8) = 2.6$ and look at some other values of n. (Received September 09, 2010)

1067-Z1-583 **Alison Ahlgren***, Department of Mathematics, 1409 West Green Street, Urbana, IL 61801, and **Marc Harper**. *Connecting student knowledge and course performance at the University of Illinois.*

Four years of assessment data at the University of Illinois reveals many interesting connections between initial knowledge of students (at the level of specific mathematical skills) and course performance. We present analysis at three levels: aggregate mathematical ability, ability in specific areas (such as trigonometry), and at the level of specific skills (such as the ability to solve equations involving rational functions).

In particular, we show a very strong relationship between aggregate mathematical ability and mean grade in precalculus, business calculus, and traditional calculus; correlations between categories of skills and correlations with grades, including cutpoints for success and failure; and correlations with specific skills and final grade.

The skills data is obtained from ALEKS assessments collected over the previous four years at the University of Illinois. The size of the data set (tens of thousands of assessments) reveals interesting connections that have been difficult to quantify previously. We will also give aggregate comparisons to ACT Math scores, which were previously used to place students. (Received September 10, 2010)

1067-Z1-590 **Jan O. Case*** (jcase@jsu.edu), MCIS Department, 700 Pelham Road North, Jacksonville, AL 36265. *Using Online Survey Tools to Consolidate Game Outcomes.*

Games and puzzles have long been a source of examples for classes in probability and statistics. Discerning patterns in risk and reward based on actual game play can be instructive, but compiling the data can be tedious and time consuming. Using online survey tools, students can enter their results as a lab activity or outside of class and the responses can be easily downloaded and distributed electronically to all members of the class. This paper presents an example using an inexpensive program called InspireData, but a number of free online survey tools are available. In an applied probability class, groups of students are given dice to evaluate. Some groups receive fair dice and others receive unbalanced dice. There are several varieties of unbalanced dice so that each group will have different experimental results. The assignment is to repeatedly roll the die, combine the results with those of the other students in the group, and perform a Chi Square goodness-of-fit hypothesis test with an appropriate conclusion. The process of entering, retrieving and distributing the data will be demonstrated along with an example of typical experiment outcomes. (Received September 10, 2010)

1067-Z1-603 **Djalalidin Djayanbaev*** (ddjayanbaev@yahoo.com), 1400 W. Blue Starr Dr. E4, Claremore, OK 74017. *Measuring discontinuities of functions.*

The discontinuities of functions in mathematical analysis are unpleasant facts for many instances. We usually prevent these difficulties by simply avoiding points where the function fails to be continuous. But some discontinuities could be thought of to be better than others. Here we will talk about ways of measuring the discontinuity of a function using a number from [0,1] called "continuity defect of the function". We will then go on to extending this concept to cases of uniform (dis)continuities. (Received September 10, 2010)

1067-Z1-630 **Rosanna Iembo*** (rosannaiembo@libero.it), via Federico Cozzolino 18, 84018 Scafati, Salerno, Italy, and **Irene Iaccarino**, via Interno Marina 19, 88900 Crotone, Italy. *The School of Empathy.*

The most important things for future of the world can be expressed in 10 E's: Earth, Equilibrium, Environment, Economy, Energy, Entropy, Engineering, Ethics, Empathy and Education. Because we are all living on the same "boat" -Earth- we must keep the world in good equilibrium. Improving the countries' economy and individual living standard cannot be at the cost of wasting energy without knowing the expenses of entropy. Solving, for example energy and environment problems depend also on good engineers, and for "producing" highly capable engineers we need good engineering education which includes also courses on ethics: through ethics people learn the respect of others and themselves. Education should also teach the philosophy of empathy- that allows students to extend their awareness from the machine to humanity care- by the Multi-Inter-Trans (M.I.T.) disciplinary learning together with the so called "meta" disciplinary thinking: for example, to integrate "liberal arts" with "military strategy" and science/engineering with culture/arts. What model ? The School of Pythagoras founded in Crotone (southern Italy), 2500 years ago. It was the school of VALUES. It "constructed" EMPATHY. During the talk a short film will be presented too. (Received September 12, 2010)

1067-Z1-644 **Jerry C. Obiekwe*** (Accessx@uakron.edu), P.O. Box 411, Orrville, OH 44667. *Assessing the Effects of Application of Cognitive Load Theory in the Teaching and Learning of Undergraduate Mathematics.*

Cognitive load essentially relates to how much cognitive activity the working memory can hold; bearing in mind that the working memory has limited space or capacity. Before information can be stored in the long term memory, it must first have a meaningful interaction with the working memory. Overloading of the working memory, which often times happens in the design of instructional materials, can slow the learning process down, particularly in domain specific subject like mathematics. Research in cognitive science has shown that by reducing the cognitive load, the learning process can be facilitated. Therefore, as mathematics educators, it is important to be cognizant of this concept when designing instructional materials that way providing a fertile ground for learning to germinate. This paper investigated the effects of reducing cognitive load in the teaching and learning of undergraduate mathematics. The results and its implications will be discussed. (Received September 12, 2010)

1067-Z1-648 **Rick E. Klima*** (klimare@appstate.edu), Department of Mathematical Sciences, Appalachian State University, Boone, NC 28608, and **Neil P. Sigmon** (npsigmon@radford.edu), Department of Mathematics and Statistics, Radford University, P.O. Box 6942, Radford, VA 24142. *Simulating a Verbal Translation of the Navajo Code; a Completed Version.* Preliminary report.

The Marine Navajo Code played a vital role in providing secret communications for the United States in the Pacific Theater during World War II, and contributed in a pivotal way in the American victory. The code has been the topic of numerous documentaries and films, including the 2002 movie Windtalkers, starring Nicolas Cage.

The code consisted of almost 700 terms. Included were translations for the English alphabet as well as common military terms. On the battlefield, the code was only spoken and never written down. It is not known to have been broken, and has been credited with saving countless lives.

In a previous talk, the presenters described a partially-completed computerized interactive translation of the Navajo Code using a Maplet. This Maplet could provide a text translation of the entire code, but could only give a verbal translation of a very limited number of codewords. However, through the assistance of a mathematics faculty member at Dinè College on the Navajo reservation in Tsaile, Arizona, the Maplet now can translate any English message into a verbal simulation using the Navajo Code.

The purpose of this talk is to give a description of the completed Navajo Code Maplet. Interactive examples will be given providing verbal simulations of the code. (Received September 12, 2010)

1067-Z1-657 **Corey M Manack*** (cmanack@indiana.edu), 225 W Reeder St., Dillon, MT 59725. *Character Estimates, and Random Walks on $SU(n)$.*

We say a compact Lie group G is *simple* if it is connected, has finite center and is a simple group modulo its center. We study the relationship between character estimates and the structure of conjugacy classes within G. Suppose G is simple and centerless; the first result shows, for n sufficiently large, the set of n-fold products from a nontrivial conjugacy class contains the identity as an interior point. This n can be chosen uniformly over the set of nontrivial conjugacy classes of G. We use this result to prove a uniform estimate on the set of normalized character values of G. In an opposite direction, we prove a different type of character estimate, which is used to bound the rate of convergence to Haar measure, for certain conjugation-invariant random walks on $SU(n)$. This convergence is with respect to the total variation distance of Diaconis and Shashahani. (Received September 13, 2010)

1067-Z1-683 **Mohsen Mahmood Doroodchi*** (mdoroodchi@stritch.edu), 6801 N. Yates Rd., Milwaukee, WI 53217, **Habibolla Latifizadeh** (latifizadehhabib@gmail.com), Shiraz University of Technology, Moddares Blvd., Shiraz, Fars, Iran, and **Esmail Hesameddini** (Hesameddini@sutech.ac.ir), Shiraz University of Technology, Moddares Blvd., Shiraz, Fars, Iran. *A novel method for solving nonlinear equations.*

The confluence of modern mathematics and symbolic computation has posed a challenge to develop methodologies capable of handling strongly nonlinear equations which cannot be successfully dealt with by classical methods. The current proposed method is uniquely qualified to address this challenge. The idea of Variational Iteration Method (VIM) is to construct a correction functional by a general Lagrange multiplier which can be identified optimally via the variational theory. The novel technique proposed in this paper provides a sequence of functions which converges to the exact solution of the nonlinear problem without requiring small parameters as the perturbation techniques and the general Lagrange multiplier in Variational Iteration Method. As an advantage of the method over decomposition procedure of Adomian, it provides the solution of the problem without calculating Adomian's polynomials. This technique solves the problem without any need to discretization of the variables. Therefore, it is not affected by computation round-off errors. It is capable of greatly reducing the volume of the computational work compared to classical methods while still maintaining high accuracy of the numerical solution. (Received September 13, 2010)

1067-Z1-691 **Ramanjit K Sahi*** (sahir@apsu.edu), Department of Mathematics, PO Box 4626, Clarksville, TN 37044, and **Samuel N Jator**, Department of Mathematics, PO Box 4626, Clarksville, TN 37044. *An Exponentially fitted Second Derivative Method for linear singularly perturbed boundary value problems.*

A numerical procedure based on an exponentially fitted Second Derivative Method (ESDM) for linear singularly perturbed boundary value problems is considered. We construct a continuous approximation of the ESDM of step number 2 that simultaneously generates additional methods which are used to provide solutions on the entire interval of the abscissa. To demonstrate the accuracy of our method, we conducted some numerical experiments. (Received September 13, 2010)

1067-Z1-732 **Adam F Childers*** (childers@roanoke.edu), MCSP Department, 221 College Lane, Salem, VA 24153. *D-Optimal Designs for Models Described by Ordinary Differential Equations.*

In general finding a D-optimal design when the number of data points is large is a very complicated optimization problem to solve. The difficulty increases even more when restrictions on the relationships between the samples, such as minimum intervals between samples, are imposed. G.E.P. Box and Lucas were the first to use D-optimal designs for non-linear models and began their work for the case when the number of sample points is the same as the number of parameters. They solved the problem geometrically by investigating the design space. Lucas expanded on this idea for the case N>p, the number of sample points N is greater than the dimension of the parameter p, and found that repeated samples at the optimal points for the case N=p were optimal or near optimal for many models. In this paper we generalize these findings so they can be applied to models described by ordinary differential equations and show how the results can be applied to design problems. (Received September 14, 2010)

1067-Z1-733 **Qingxia Li*** (liq@lincolnu.edu), 1133 Ashland Road, Apt 1612, Columbia, MO 65201. *Optimal Control.*

This paper examines the value function with associated Lagrangian being measurably time-dependent. For such value functions, we cannot take the subgradient by the point evaluation, instead by the essential values of the Hamiltonians. Furthermore, we demonstrate that such value functions satisfy a subgradient" form of the Hamilton-Jacobi equations (Received September 14, 2010)

1067-Z1-738 **Hieu D Nguyen*** (nguyen@rowan.edu), Rowan University, Department of Mathematics, 201 Mullica Hill Rd., Glassboro, NJ 08028. *A Combinatorial Formula for Certain Two-Dimensional Sequences Related to Generalized Bernoulli Polynomials.* Preliminary report.

We present a new combinatorial formula for solving a certain family of two-dimensional sequences, defined recursively by $x_{n,p} = a_{n,p-1}x_{n,p-1} + b_{n,p-1}x_{n-1,p-1}$, that involves some interesting counting functions on subsets of the natural numbers. These sequences arise in certain explicit formulas for generalized Bernoulli polynomials. (Received September 14, 2010)

1067-Z1-742 **A. S. Elkhader*** (elkhadea@northern.edu), Dept. of Mathematics & Natural Sciences, Northern State University, 1200 S. Jay St., Aberdeen, SD 57401. *Maximizing the Benefit of a Review Session Using an Informal Collaborative Group Format.*

An informal collaborative learning group format is used in this work. Two classes, Calculus III and Differential Equations, are used for comparison. A collaborative format used in the differential equations class, while a standard question/answer format is used in the calculus class. Numerous learning parameters are kept under control except the collaborative learning format. In the differential equations class students are divided into groups of three or four students each. Review problems, which are requested by students or selected by the instructor, are spaced out on the whiteboard around the room. Each group, which is formed by the instructor, is volunteered to work on one of problems. A member from each group is asked to write down a complete solution on the board, and to present that work to the entire class. Students' interviews and perception of the collaborative learning environments, as well as their performance in class in terms of mathematical writings and grades will be shared. (Received September 14, 2010)

1067-Z1-795 **Timothy Prescott*** (timothy.prescott@und.edu), UND Mathematics Department, Witmer Hall 313, 101 Cornell Street Stop 8376, Grand Forks, ND 58202-8376. *Shape Theorems For Evolving Sets on Two Dimensional Lattices.*

Evolving sets are dual to random walks on a lattice, allowing the underlying geometry to aid intuition about the original walk. Local limit laws show that two dimensional random walks have transition probabilities that are eventually circular, leading one to expect a two dimensional evolving set to be eventually circular as well. We prove, however, that on three common lattices, the shape is always a semi-regular polygon, and we show that the limiting law defining this polygon is given by a two parameter stochastic diffusion. (Received September 14, 2010)

1067-Z1-837 **John C. Chrispell*** (jchrispe@tulane.edu), Tulane University, 416 Stanley Thomas Hall, New Orleans, LA 70118, and **Lisa J. Fauci**. *Immersed elastic structure dynamics in viscoelastic fluids.*

Many biological fluids are non-Newtonian and exhibit viscoelastic responses. Here we discuss recent results obtained using an immersed boundary framework to study the interaction between immersed elastic structures and surrounding viscoelastic fluids. (Received September 15, 2010)

1067-Z1-845 **Jesse E Miller*** (jemille1@math.uiuc.edu), 1409 West Green Street, Urbana, IL 61801. *A Blended Approach to Teaching Finite Mathematics at the University of Illinois.* Preliminary report.

Finite Mathematics at The University of Illinois has been taught in a blended format for the past two years. Half of the content is delivered online, and half is delivered in the classroom. The online component consists of lectures that cover the course material, and the in-class component consists of group activities. The lecture videos are viewed prior to class. The in-class activities are designed to lead the students through the conceptual understanding of the material covered in the lectures. The primary role of the instructor is to guide the students by giving targeted help when questions arise. As a result, the students, rather than the instructors, are the moving force in the classroom. This leads to better understanding of the material than a lecture-only approach, and allows no students to fall behind unknowingly. We have seen increased student success and student learning, and the course is deployed at a reduced expense. The videos were created in-house, and thus we have maintained control over the content. (Received September 15, 2010)

1067-Z1-862 **J Marshall Ash*** (mash@math.depaul.edu), Mathematics Department, DePaul University, Chicago, IL 60614-3250, and **T. Kyle Petersen** (tkpeters@math.depaul.edu), Mathematics Department, DePaul University, Chicago, IL 60614-3250. *Families of proofs that the prime numbers are infinite.* Preliminary report.

We propose the exercise of finding infinite families of proofs that the primes are infinite. We give several examples. One example is this. Assume that the number of primes is finite. Let k be a positive integer. For the kth proof note that the Riemann zeta function evaluated at $2k$ is irrational. There is a well known product formula of Euler that shows that if the number of primes is finite, then the Riemann zeta function evaluated at $2k$ must be rational. This contradiction completes the kth proof. (Received September 15, 2010)

1067-Z1-867 **Rebecca Boone*** (arboon@alum.calberkeley.org), 285 NW 35th Street, #76, Corvallis, OR 97330. *Language, Gender, and Number.*

Math claims to communicate as a 'language' yet ignores the gender case and number of its devoted believers and teachers as well as those of possible learners it ardently courts and hopes to hook belief-wise. I ask, how come? Human language consists of female and male voices and a voiceless neuter 'it'. First, second, and third 'persons' indicate nature's numerical order. No teacher can dissemble the gender orientation of its voice. Discounting language's spoken and written words, I conclude that pure number is ontologically dis-quotational and that everything correctly surmised about numerical differentiations, functions, and relationships is realized biologically by females alone – but necessarily post motherhood. Mothers do not usually confront their biological issues philosophically. In their precious academic 'courses', could math professionals possibly throw their most brilliant light on mankind's ultimate numerical, sexual, and philosophical problems as reflected socially? I hope so. (Received September 15, 2010)

1067-Z1-870 **Doreen De Leon*** (doreendl@csufresno.edu), 5245 North Backer Avenue, M/S PB108, Fresno, CA 93720. *Undetermined Coefficients – Not Just for Constant-Coefficient Equations Anymore.* Preliminary report.

Recently, an exam given in my upper division differential equations courses contained a problem asking for the general solution of

$$ty'' - (2t+1)y' + (t+1)y = 8t^3e^t,$$

given the complementary solution. To my amazement, one student correctly found the particular solution to this problem by using undetermined coefficients! This led me to wonder what other types of equations can be solved using undetermined coefficients. In this presentation, we will discuss two results in answer to this question. (Received September 16, 2010)

1067-Z1-884 **William E Wood*** (wood@hendrix.edu), 1600 Washington Ave, Conway, AR 72032.
Squigonometry: Using Calculus to Develop New Transcendental Functions. Preliminary report.

The circle is ubiquitous in mathematics, and it is easy to take it for granted. We look to enhance our appreciation of the circle by developing an analog of trigonometry – a subject built upon analysis of the circle – for something that is *not quite* a circle. Our primary model will be the unit squircle, the superellipse defined as the set of points (x, y) in the plane satisfying $x^4 + y^4 = 1$. We will use an elementary initial value problem approach to develop functions that parameterize the squircle and behave much like their trigonometric analogs.

The ideas require only calculus, but take students through ideas in non-euclidean geometry, elliptic integrals, and complex analysis. The material has been used as a writing project in the second semester of an initial value problem-based calculus sequence. We will discuss this overall approach and how this topic provides students with opportunities to challenge their understandings of what it means to define new functions and how to balance computation with theory toward discovering and proving theorems about them. (Received September 16, 2010)

1067-Z1-900 **Erin Elizabeth Bancroft*** (erin_bancroft@ncsu.edu), 2108 SAS Hall, Box 8205, Raleigh, NC 27695. *The Shard Intersection Order on the Symmetric Group.*

The shard intersection order is a new lattice structure on a finite Coxeter group W which encodes the geometry of the reflection arrangement and the lattice theory of the weak order. In the case where W is the symmetric group, we define a bijection between shard intersections and certain pre-orders which we call permutation pre-orders. We use this combinatorial characterization to determine properties of the shard intersection order. In particular, we give an EL-labeling. (Received September 16, 2010)

1067-Z1-928 **Stan Perrine*** (sperrine@csuniv.edu). *How Do You Get Students Involved in Writing Proofs? One (Method) at a Time.* Preliminary report.

When are students formally introduced to the art of writing proofs? In a typical undergraduate curriculum, this focus happens in a "bridge" course - typically titled "Intro to Advanced Math" or sometimes more nebulously, "Discrete Math". This talk will focus not on the content of the "bridge" course, but the order of topics from a pedagogical nature. For most, these courses have an introduction to logic and the different basic proof techniques, and then the techniques are showcased in subsequent chapters, each of which focuses on a specific subject area - groups, number theory, analysis, etc... My proposal (to be first implemented in my course this coming spring) is to invert the two - after an introduction to logic, each subsequent "chapter" will focus on one proof technique - direct, contradiction, induction, etc... and focus on applying that technique over and over to multiple branches of mathematics, with the (anticipated) result of better retention of the proof techniques by the students, even in lieu (possibly) of full retention of the definitions and theorems themselves. (Received September 16, 2010)

1067-Z1-931 **Jonathan Kane** (kanej@uww.edu), 2814 Regent Street, Madison, WI 53705-5218, and **Janet Mertz*** (mertz@oncology.wisc.edu), 2814 Regent Street, Madison, WI 53705-5218.
Mathematics Performance of Boys Correlates with Gender Equity.

Boys sometimes, but not always, outperform girls in mean mathematics performance; thy usually, but not always, exhibit greater variance in score distribution. Analysis of data from the 2007 Trends in International Mathematics and Science Study shows that greater variance in boys' scores has a strongly negative correlation with gender gap in mean performance. Both variance ratio and gap are unrelated to a nation's wealth, predominant religion, or gender-segregated schooling. Instead, they are largely effects of socio-cultural factors and some boys performing quite poorly. Importantly, mathematics performance at the low, medium, and high levels for boys as well as girls has a strongly positive correlation with some measures of gender equity. (Received September 16, 2010)

1067-Z1-954 **Stanley F. Florkowski*** (stanley.florkowski@usma.edu), Dept. of Math Sciences, United States Military Academy, 646 Swift Road, West Point, NY 10996. *Title: Enhancing Calculus with Technology Labs, and getting your students to like it!*

Calculus teachers often question how to best integrate technology, such as computer algebra systems (CAS), into their classes. At the U.S. Military Academy at West Point, six lessons in the Multivariable Calculus class are taught as "technology labs" in which the students solve two or three Calculus problems on computers using an assigned CAS (we use Wolfram's Mathematica©). The labs allow the students to focus on setting up the problem, then use the CAS to solve it, then finally and most importantly, provide a graph of the problem, which enables them to better visualize the Mathematics they are studying on a deeper level than with just pen and paper. The stumbling block we encountered the first semester we incorporated these technology labs was that many students quickly became frustrated with the syntax of the software, were not able to complete the assigned problems, and ultimately missed the learning benefits of the labs. In the subsequent semesters, we have made significant improvement on the implementation these technology labs. We will share these lessons learned and provide ways teachers can prevent student frustration with the software and have their students confidently learn and use the CAS to significantly enhance their learning of Mathematics. (Received September 16, 2010)

1067-Z1-1019 **Michael J Bardzell*** (mjbardzell@salisbury.edu), Dept. Math and CS, Salisbury University, Salisbury, MD 21801. *Building a Noncommutative Ring from a Finite Directed Graph.* Preliminary report.

In this talk we will describe an interesting class of noncommutative rings which can be constructed using finite directed graphs. This construction also creates a vector space. These structures provide undergraduate students connections between ring theory and graph theory and, among other things, allow them to see a ring unity element that looks quite different from the ones they are accustomed to using. (Received September 17, 2010)

1067-Z1-1020 **Michael S. Gagliardo*** (mgaglia@ju.edu), Division of Science and Mathematics, Jacksonville University, 2800 University BLVD N., Jacksonville, FL 32211. *Comparison of Student Performance between Inquiry Based Learning and Lecture Methods when Teaching Induction.* Preliminary report.

In the Spring of 2010, I taught our introduction to proofs class using a fully inquiry based technique. Final exams scores from common questions on mathematical induction were compared. One of the classes was taught using a lecture method while the other was taught using an inquiry based method. This talk will discuss the results. (Received September 17, 2010)

1067-Z1-1027 **Natali Hritonenko*** (nahritonenko@pvamu.edu), Department of Mathematics, Prairie View A&M University, Prairie View, TX 77446, and **Lauretta Byars** and **Alisha Lowe**. *Service-learning in Mathematics Curriculum.* Preliminary report.

Service-learning is a method of teaching and learning that enriches students' academic lives while fostering a sense of responsibility for others. This pedagogical tool requires faculty to reexamine their course design and incorporate strategies that enhance students' knowledge and sense of civic engagement, while preparing them for future careers. This presentation will focus on how service-learning activities are incorporated into upper level mathematics courses' curriculum. This novel approach uses students in lower level mathematics courses, such as algebra, trigonometry and calculus, as the community partner. Participating in service-learning, the advanced calculus students improved their knowledge of mathematical concepts and academic performance. It also challenged the advanced calculus students to consider their role while helping other students. The benefits of implementing service-learning as well as advantages and disadvantages of service-learning from the perspective of mathematics majors will also be addressed in the presentation. (Received September 17, 2010)

1067-Z1-1039 **Lilinoe M. Harbottle*** (lmharbottle@csupomona.edu), Cal Poly Pomona, 3801 West Temple Avenue, Department of Mathematics and Statistics, Pomona, CA 91768, **Blake Hunter** (blakehunter@math.ucdavis.edu), University of California, Davis, Department of Mathematics, One Shields Avenue, Davis, CA 95616, and **Alan Krinik** (ackrinik@csupomona.edu), Cal Poly Pomona, 2801 West Temple Avenue, Department of Mathematics and Statistics, Pomona, CA 91768. *The General, Irreducible Three and Four-State Markov Process.*

When introducing Markov processes, the natural first example that students learn is the two-state Markov process. This simple example is important for illustrating both the meaning and how to find steady state distributions and transient probability functions. One might think that the next most elementary examples of Markov processes would be the three or four-state Markov processes. However, this is not usually the case. In fact, the solution of the general, irreducible three-state Markov process does not (as far as we know) appear in introductory texts on Markov processes.

To address this gap in the pedagogy of Markov process, we present a solution method and formulae for the steady state distribution and transition probably functions of the general, irreducible three and four-state Markov process. The structure of the formulae illustrates some interesting connections between steady state and transient behavior. The solutions have been programmed which facilitate quick comparisons between different models of Markov processes. The analysis also has consequences for systems having more than three or four states. Hopefully, these simple examples will assist students to develop a better understanding of Markov processes. (Received September 17, 2010)

1067-Z1-1070 **Eric D. Bancroft*** (eric_bancroft@ncsu.edu), Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695-8205. *Parabolic Monoids of Matrices.*

The Renner decomposition for reductive, algebraic monoids is an analogue of the Bruhat decomposition. In the monoid of upper triangular matrices, $\overline{B} = T_n(k)$, Renner's decomposition gives $\overline{B} = \coprod_{r\in R^+} BrB$, where B is the Borel subgroup of upper triangular invertible matrices and R^+ is the set of upper triangular partial permutation matrices. Then $\overline{B} \supseteq \overline{P}$, where $\overline{P}$ is the parabolic monoid of block upper triangular matrices. We look at conditions for elements of $\overline{P}$ to be a product of idempotents in $\overline{P}$ and describe this product for several cases. (Received September 17, 2010)

1067-Z1-1073 **Kapila Rohan Attele*** (kattele@csu.edu), Department of Mathematics, HWH 332, Chicago State University, 9501 South King Drive, Chicago, IL 60615, **Dan Hrozencik**, IL , and **Victor Akatsa**, IL. *Introduction to Abstract Algebra Based on Computational Algebra with Applications Drawn from Biology.*

Students are introduced to real analysis based a platform of computational experience gained in calculus. There is no comparable student experience in learning introductory abstract algebra. The disconnect between students' background of calculus and linear algebra, and the concepts and practices in abstract algebra makes teaching and learning the subject a challenge.

The advent of applications of algebraic geometry and commutative algebra to biology provides a fillip to examine what should an introductory abstract algebra course be and material for a supportive sophomore course in computational algebra. The authors will present a more commutative algebra oriented curriculum for introductory abstract algebra and a prerequisite computational algebra course. (Received September 18, 2010)

1067-Z1-1128 **Salam Md. Mahbubush Khan*** (khan@math.fsu.edu), Department of Mathematics, Alabama A&M University, 4900 Meridian Street, Normal, AL 35762. *Stochastic dynamical model of social conflict and cooperation.*

Here we introduced a stochastic dynamical conflict model for multi-opponent and consider the associated dynamical system for a finite collection of positions. Opponents have no strategic priority with respect to each other. The conflict interaction among the opponents only produces a certain redistribution of common area of interests. The limiting distribution of the conflicting areas, as a result of 'infinite conflict interaction for existence space, is investigated. Next we extend our conflict model and propose conflict and cooperation model, where some opponents cooperate with each other in the conflict interaction. Here we investigate the evolution of the redistribution of the probabilities with respect to the conflict and cooperation composition, and to determine invariant states by using computer simulation. (Received September 19, 2010)

1067-Z1-1143 **Gerald M. Higdon*** (ghigdon@fitchburgstate.edu), Department of Mathematics, Fitchburg State University, Pearl St., Fitchburg, MA 01420. *Rectangular to Polar Transformations.* Preliminary report.

When transforming from polar to rectangular coordinates the transforming functions are well known and easy to apply. In the reverse transformation the problem is more subtle for the polar angle. Most texts gloss over this problem indicating that $\tan\theta = \frac{y}{x}$ "solves the problem" and then add some remarks about adjusting the solution to this equation for various quadrants. This talk will present several closed form functional representations of θ as a function of x and y. Properties of these functions and relationships between them will be discussed as well as deriving techniques and suggestions for classroom usage. (Received September 21, 2010)

1067-Z1-1158 **Samuel M Hansen*** (samuel@acmescience.com), 5241 Caspian Springs Dr, Unit 204, Las Vegas, NV 89120. *Math vs. Maths: A Yankee Mathematician in Sir Isaac's Court.*

In November Samuel Hansen will take a mathematical speaking tour of England. It is mathematical outreach efforts on the internet that has facilitated this opportunity. During the trip Samuel will travel to various universities, and interact with well known British mathematical popularizers, to take part in different styles of outreach efforts, including: live podcast recording, lectures, and a mathematical history tour of Nottingham. During his talk Samuel will discuss the differences between mathematical outreach and culture of the two countries, i.e. the Math of the USA and the Maths of the UK. (Received September 19, 2010)

1067-Z1-1162 **Rachel Esselstein*** (resselstein@csumb.edu), 100 Campus Center Dr., Building 53, Seaside, CA 93933. *Improving Support for Undergraduate Math Tutors.* Preliminary report.

Like many universities, California State University, Monterey Bay, has a campus-run student service center where undergraduate tutors provide support for lower-division mathematics courses among other things. It used to be that the mathematics department had very little interaction with the tutoring center and no control over affairs such as the hiring or assigned classes for student tutors. As part of a larger College Cost Reduction and Access

Act (CCRAA) grant, the mathematics department was suddenly invited to participate in the strengthening and development of the mathematics tutoring program.

In this talk I will outline the changes we made including the creation of a hiring and interview process, course-specific manuals for the student tutors, and a course required of the student tutors covered under the grant. Each of the changes we made were easy to implement and cost-effective. Furthermore, the data we collected after one year of implementation of these changes showed a significant improvement over the student, faculty and tutor satisfaction with the mathematics tutoring program. (Received September 19, 2010)

1067-Z1-1216 **Vicky W Klima*** (klimavw@appstate.edu), Department of Mathematical Sciences, Appalachian State University, Boone, NC 28608. *Writing for Understanding in Calculus III.* Preliminary report.

Instructors frequently use writing as a measure of evaluating students' understanding, but writing along with guided peer review can sometimes be better used to help students build their understanding, organize their thoughts, and extend their knowledge. This presentation describes a series of Calculus III writing assignments designed with the latter purpose in mind. Students write a solution to one of several problems as if they were teaching the problem-solving process to a peer, and then each student reviews his or her peers' solutions to the remaining problems, participates in round-table writing discussions, and uses the advice of his or her peers to improve his or her own solution. The presentation will also address instructor evaluations of the writing process. (Received September 20, 2010)

1067-Z1-1250 **Peter L Staab*** (pstaab@fsc.edu), Department of Mathematics, 160 Pearl St., Fitchburg, MA 02130. *Using a Wireless Tablet to Lecture in Mathematics Classes.* Preliminary report.

A wireless tablet is a drawing device for a computer that can be ported around in a classroom. It can be used similar to that of a Smartboard, with some similarities, but also differences. I just started using the tablet for lecturing for the first time and I will discuss how I have used this device in my mathematics classroom this semester, how it has changed some of my teaching style, and how the students have reacted to it. There are some unique challenges and opportunities that are presented when using such a tools in a mathematics classroom which I will also address. (Received September 22, 2010)

1067-Z1-1254 **Agnes M Rash*** (arash@sju.edu), Mathematics Department, 5600 City Avenue, Philadelphia, PA 19131. *An Inhibitor to Learning College Level Mathematics Math Anxiety: Problems and Proposed Solutions.*

One of the issues related to the mathematics learning among nonmathematics and nonscience majors is math anxiety. This research addresses the question: Can math anxiety be reduced in college students by changing the pedagogy of the course to include inquiry-based instruction, games and puzzles? A study is being conducted in Fall, 2010 to measure the effects of this pedagogical approach in a course. A pretest-posttest design with matched pairs will be used to analyze the results. There is a control group of calculus students for comparison. The presentation will describe the research outcomes, and the puzzle and game will be introduced to the audience. A goal of the research is to find ways to reduce anxiety among elementary education majors. A large number of the students involved in the study are elementary education majors. I hope to gain some insight into this particular group of students using a subset of the data. (Received September 20, 2010)

1067-Z1-1261 **Melissa A Stoner***, 14 E Packer Ave, Bethlehem, PA 18015, and **Linghai Zhang**, 14 E Packer Ave, Lehigh University, Bethlehem, PA 18015. *Existence and Stability of Standing Wave Solutions Arising from Synaptically Coupled Neuronal Networks.*

There have been many models of neuronal networks developed and analyzed to determine the wave and speed of the wave in a nerve pulse. The goal of this research is to investigate the existence and stability of standing wave solutions of the system of integral differential equations

$$\begin{aligned} \frac{\partial u}{\partial t} + f(u) + w &= (\alpha - au)\int_0^\infty \xi(c)\left[\int_{\mathbb{R}} K(x-y)H\left(u\left(y, t-\frac{1}{c}|x-y|\right)-\theta\right)\mathrm{d}y\right]\mathrm{d}c \\ &+ (\beta - bu)\int_0^\infty \eta(\tau)\left[\int_{\mathbb{R}} W(x-y)H\big(u(y,t-\tau)-\Theta\big)\mathrm{d}y\right]\mathrm{d}\tau, \\ \frac{\partial u}{\partial t} &= \epsilon\big(g(u)-w\big). \end{aligned}$$

These model equations generalize many important integral differential equations used in most recent related papers when modeling neuronal networks. For the system of integral differential equations, if $f(u) + g(u) = m(u-n) + k(u-l)$ and conditions on the constants and kernel functions are satisfied then there exist two standing waves. Additionally, the stability of the standing wave is dependent on the network's parameters.

The results for the system are surprisingly interesting in mathematical neuroscience, especially this change in stability. (Received September 20, 2010)

1067-Z1-1265 **Entao Liu*** (liuentao@gmail.com), 1523 Greene St, Columbia, SC 29208. *Super Greedy Type Algorithms.*

The general theory of greedy approximation is well developed. Much less is known about how specific features of a dictionary can be used for our advantage. In this talk we discuss incoherent dictionaries and build several new greedy algorithms which are called the Super Greedy Type Algorithms. This type of algorithms are more efficient than a standard Greedy Algorithms. We analyze the rates of convergence with respect to incoherent dictionaries. (Received September 20, 2010)

1067-Z1-1266 **Stephen R Muir*** (srm0070@unt.edu), Stephen Muir, Department of Mathematics, 1155 Union Circle #311430, Denton, TX 76203. *Gibbs Measures for Unbounded Local Energy Functions on $\mathbb{N}^{\mathbb{Z}^d}$.*

In statistical mechanics, the metric space $\mathbb{N}^{\mathbb{Z}^d}$ serves as a classical lattice model with a countable infinity of possible states at each lattice site. We introduce a definition of Gibbs state(probability measure) for suitable functions $f : \mathbb{N}^{\mathbb{Z}^d} \to \mathbb{R}$, which play the role of negative *local energies*, i.e. specific internal energies. We emphasize that we work solely with a local energy function and need no reference to an interaction potential. Conditions on f ($(d-1)$-*regularity* and *exp-summability*) are provided which guarantee the Gibbs states for f to be a nonempty, compact(weak topology), convex set of measures. We characterize them as exactly those probability meausres that obey a local-energy version of the famous DLR(Dobrushin-Lanford-Ruelle) equations. We show too that the variational characterization holds: shift invariant Gibbs states are precisely the states maximizing the negative free energy functional. For the smoother class of d-regular exp-summable functions we can show, c.f. H.O. Georgii, how to convert to an equivalent system consisting of a finite measure and strongly summable interaction potential, which is the standard starting point in the literature. (Received September 20, 2010)

1067-Z1-1271 **Jacqueline Anderson Hall*** (hallja@longwood.edu), HS Box 72, Hampden Sydney, VA 23943. *Teaching Basic Number Theory from the Sieve of Eratosthenes.*

Given a natural number n, the Sieve of Eratosthenes is an algorithm for finding all prime numbers between 1 and n. I teach a Liberal Arts mathematics course, Mathematical Thinking, specifically targeted at the "I can't do math" student. The first homework includes using the Sieve of Eratosthenes to find all primes between 1 and 200. This pedestrian assignment is actually a foundation stone for the rest of the course. From here we prove: 1. What does it mean to be a multiple of 3 or 5 or 7? 2. Could 1 more than a multiple of 7, that is 7k+1, ever be a multiple of 7? 3. What are the possible remainders when one divides by 7? 4. Extend the "Even/Odd" partition notion of multiples of 2 to other multiples. Think in terms of remainders. Using patterns observed in the Sieve of Eratosthenes we are able to show that: There are an infinite number of primes (#2). An odd times odd is always odd (#2). Any rational number m/n can be written as a repeating decimal (#3). The square root of 3 is irrational (#1). Hilbert's Hotel can accommodate three infinitely full busses (#4). We can do modular arithmetic (#4).

The Sieve of Eratosthenes does motivate much of a Mathematical Thinking Course! (Received September 20, 2010)

1067-Z1-1290 **Daniel P. Wisniewski*** (Daniel.Wisniewski@desales.edu), Department of Mathematics/Computer Science, DeSales University, 2755 Station Avenue, Center Valley, PA 18034, and **Helen G. Grundman** (grundman@brynmawr.edu), Department of Mathematics, Bryn Mawr College, 101 N. Merion Avenue, Bryn Mawr, PA 19010. *Tetranomial Thue Equations of Small Degree.* Preliminary report.

A Thue equation is one of the form

$$|F(x,y)| = 1,$$

where F is a homogeneous, irreducible polynomial in $\mathbf{Z}[x,y]$ of degree at least three. We consider the particular problem of bounding the number of integer solutions (p,q) to the *tetranomial* Thue equation, where

$$F(x,y) = a_0x^n + r_0x^my^{n-m} - s_0x^ky^{n-k} + t_0y^n,$$

with $n > m > k > 0$, $a_0 > 0$, and $r_0, s_0, t_0 \neq 0$, such that

$$0.99a_0n > |r_0|m \qquad \text{and} \qquad 0.99|t_0|n > |s_0|(n-k).$$

In this talk, I will summarize the methods we used to prove that if $n \geq 50$, then the tetranomial Thue equation $|F(x,y)| = 1$ has at most 36 solutions $(p,q) \in \mathbf{Z}^2$ with $|pq| \geq 2$ (where (p,q) and $(-p,-q)$ are counted as a single solution). I shall also discuss our recent work on calculating comparable upper bounds when the degree of this Thue equation is less than 50, and note how the previous approach and techniques need to be modified. (Received September 20, 2010)

1067-Z1-1300 **James E. Hamblin*** (jehamb@ship.edu), 1871 Old Main Drive, Shippensburg University, Shippensburg, PA 17257. *Doing It Yourself: Writing Your Own Textbook.*

Many of us have considered writing our own textbook for a math course for various reasons. Sometimes it is hard to find a book that perfectly matches what you want to do. Sometimes you just get fed up with steadily rising textbook costs. There are many reasons **not** to do it, but many of us don't write our own textbooks simply because we don't know how to get started.

In this talk I will discuss how I got started writing my own textbook for a general education math course, what I did right, what I did wrong, and some tips for anyone who is considering it. (Received September 20, 2010)

1067-Z1-1321 **Roland Minton*** (minton@roanoke.edu), 221 College Lane, Department of Mathematics, Salem, VA 24153. *Puttering Around with Golf Statistics.* Preliminary report.

In professional tournaments, golf statistics are recorded with great detail. The position of the ball before and after each shot is measured to the inch. With such a wealth of data, statistical explorations of golf statistics can now uncover numerous oddities. Do players tend to hit shots too long or too short? An interesting graphical artifact is found in the analysis. Do players putt better when going for par or for birdie? Does the type of grass on the green affect putting efficiency? These and other questions will be addressed. (Received September 20, 2010)

1067-Z1-1352 **Joy L. Becker*** (beckerjoy@uwstout.edu), UW-Stout, MSCS Dept., 231 Jarvis Hall Science Wing, Menomonie, WI 54751, and **Laura J. Schmidt**. *Improving Learning Through a Lesson Study Community of Practice.* Preliminary report.

Lesson study and communities of practice strive to capitalize on the benefits of collaboration. During the 2009-10 academic year, faculty at the University of Wisconsin-Stout and Eau Claire participated in a community of practice on implementing lesson study and completed several lesson study projects. This talk will highlight experiences from that community, including assessment of student learning during the projects, and the benefits and challenges of participating in such projects. Resources for participants interested in starting a lesson study project or community of practice of their own will be shared. (Received September 20, 2010)

1067-Z1-1353 **Laura J Schmidt*** (schmidtlaur@uwstout.edu), UW-Stout MSCS Department, 231 Jarvis Hall Science Wing, Menomonie, WI 54751, and **Joy L Becker**. *Closing the Gap Between Learners' and Instructors' Expectations.* Preliminary report.

What happens when you discuss expectations for yourself, your students, and your class? Do clear expectations increase motivation? During 2010, these questions were investigated by a multidisciplinary group of faculty at the University of Wisconsin-Stout. This talk will discuss the results based on student surveys and course evaluations. This project was supported by a University of Wisconsin-System OPID grant. (Received September 20, 2010)

1067-Z1-1371 **John C Mayer*** (jcmayer@uab.edu), Department of Mathematics- CH 452, University of Alabama at Birmingham, Birmingham, AL 35294-1170. *Can Mathematics Be Taught? Revisiting Carl Linderholm's "Mathematics Made Difficult".*

Carl E. Linderholm's "wacky" book (to quote the MathSci review) "Mathematics Made Difficult," first published in 1971 (in the US, 1972), is a thought-provoking and amusing adventure through mathematical understandings and misunderstandings. At heart it exposes us to the danger of asking questions. The meta-question it raises for the reader is: Can mathematics be made easy? (Received September 20, 2010)

1067-Z1-1399 **Martin E. Flashman*** (flashman@humboldt.edu), Department of Mathematics, Humboldt State University, Arcata, CA 95521. *Two Different Approaches to Getting Students Involved in Writing Proofs.* Preliminary report.

The author will present two different approaches he has used to engage students in developing and editing proofs- both important aspect of the art of writing. First is making a systematic analysis of a given proof to understand alternatives in style of presentation. The second is the use of "proofs without words" for exercises in transforming nonverbal thoughts and arguments into readable verbal presentations of the related argument or "proof." (Received September 20, 2010)

1067-Z1-1405 **Ethan Berkove*** (berkovee@lafayette.edu), Department of Mathematics, Lafayette College, Easton, PA 18042. *The (Colored Cubes)^3 Problem.*

There are 30 ways to color a cube with six colors where each face is one color. Starting with a collection of the 30 distinct cubes, it is well-known that one can find 27 cubes which can be stacked into a larger $3 \times 3 \times 3$ cube where each 3×3 face is one color. More generally, given an arbitrary collection of n^3 cubes, when it is possible to assemble the cubes into a larger $n \times n \times n$ cube where each $n \times n$ face is one color? We will answer this question, which was the subject of a summer REU project, and provide some related open questions. (Received September 20, 2010)

1067-Z1-1409 **Tin-Yau Tam*** (tamtiny@auburn.edu), Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849-5310. *A. Horn's result on matrices with prescribed singular values and eigenvalues.* Preliminary report.

We give a new proof of a classical result of A. Horn on the existence of a matrix with prescribed singular values and eigenvalues. (Received September 20, 2010)

1067-Z1-1415 **Joy Marie D'Andrea*** (jdandrea@mail.usf.edu), 6200 Sturgis Street, Englewood, FL 34224. *Discussing Symmetries of Polyhedra on their Structures.*

A polytope is a geometrical figure bounded by portions of finitely many lines, planes, or hyperplanes. In two dimensions it is a polygon, in three a polyhedron. We study the symmetries of a polyhedron to help us understand the structure of the polyhedron, where a symmetry is a motion that leaves the polyhedron unchanged. In this talk the author will present some examples of polyhedra, and their symmetries on their structures. These structures make up what we will define as *CW-Complexes* of polyhedra. This is applicable to educational purposes for teaching elementary, middle, and high school students how to understand geometric shapes, and develop more three-dimensional thinking skills.

Keywords: Polyhedra, Geometry, Platonic Solids, Math Education, Polyhedral Structures. (Received September 20, 2010)

1067-Z1-1449 **Bret Jordan Benesh*** (bbenesh@csbsju.edu), 37 College Avenue South, St. Joseph, MN 56374. *Adventures with Cooperative Learning and standards-based grading in the college classroom (or, how I tried to re-program myself to teach in only one semester).* Preliminary report.

After reading much research on Cooperative Learning and the effects of grading on students, I decided to do a complete overhaul on how I ran my Linear Algebra and Essential Calculus classes this semester.

First, I decided to use a Cooperative Learning (CL) structure in my classes. More than just "group work," CL is a method that has 115 years of research to support it.

Second, I decided to use a "standards-based grading" system. This was designed to give my students detailed feedback on what they understand (or don't) and minimize the emphasis on grades. In short, standards-based grading organizes scores according to topic rather than chronology.

Finally, I will discuss issues of implementation (how do you do CL when classes are only 70 minutes long?), successes, failures, lessons learned, and the wisdom (or lack thereof) of making two huge changes to one's teaching at once. I will provide an overview of the research that led me to make these changes, and I will provide anecdotal evidence on how well each worked. (Received September 21, 2010)

1067-Z1-1470 **Deirdre L Smeltzer*** (smeltzed@emu.edu), 1200 Park Road, Harrisonburg, VA 22802, and **Owen D Byer** (byer@emu.edu), 1200 Park Road, Harrisonburg, VA 22802. *Comparing Circular and Spherical Inversions.* Preliminary report.

Most mathematicians are likely familiar with inversion of a plane with respect to a circle. An inversion "erases" the distinction between lines and circles, often demonstrating that apparently unrelated geometric properties are actually equivalent.

In this talk we generalize this concept to inversion of 3-space with respect to a sphere and its properties. We introduce some generalizations of problems from 2-space for which spherical inversion solutions seem promising. This talk serves as in introduction for the talk "Applications of Spherical Inversions." (Received September 21, 2010)

1067-Z1-1476 **Owen D Byer*** (byer@emu.edu), 1200 Park Road, Harrisonburg, VA 22802, and **Deirdre L Smeltzer** (smeltzed@emu.edu), 1200 Park Road, Harrisonburg, VA 22802. *Applications of Spherical Inversions.* Preliminary report.

In this talk we briefly review inversion of 3-space with respect to a sphere and give examples of results from solid geometry that can be proven using such an inversion. This is a powerful but seemingly seldom-used technique. This talk applies the ideas given in the talk "Comparing Circular and Spherical Inversions." (Received September 21, 2010)

1067-Z1-1484 **Trent C Kull*** (kullt@winthrop.edu), Mathematics Department, Winthrop University, Rock Hill, SC 29733. *Demystifying the Dirac Delta "Function".* Preliminary report.

The Dirac Delta function is often presented to undergraduates in an introductory differential equations course in a manner that may disguise its defining characteristics. Having students explore various approximations to the delta during Laplace transform solution methods may assist students in their efforts to gain a deeper understanding of this strange "function." We will look at several related student exercises that emphasize the nature of limits, continuity, differentiability, solutions to initial value problems, and the use of impulses in mathematical modeling. (Received September 21, 2010)

1067-Z1-1488 **Mary Ann Barbato*** (msaadi@fitchburgstate.edu), Fitchburg State University, Mathematics Department, 160 Pearl Street, Fitchburg, MA 01420-2697. *Improving Elementary Teacher Mathematics Preparation at Fitchburg State University.* Preliminary report.

In 2008, Fitchburg State University (FSU) changed their mathematics requirements for pre-service students which included developing two new courses and increasing the number of required mathematics courses for elementary education students from 2 to 3. One of the new courses is essentially a college algebra course designed for future teachers and corresponds to the Patterns, Functions and Algebra strand of the Massachusetts Curriculum Framework. This presentation will summarize grant and sabbatical activities that helped fine tune this course as well as some other ideas for improving the mathematics preparation of future elementary teachers in Massachusetts. (Received September 21, 2010)

1067-Z1-1505 **Garry S Bowlin*** (bowlin@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University, Binghamton, NY 13902-6000. *Examples of Highly Frustrated Matrices.*

For an $n \times m$ matrix M with entries in $\{0, 1, -1\}$, the frustration index is the least number of negative entries of D_1MD_2 over all D_1, D_2 diagonal ± 1 matrices. An $n \times n$ matrix H is said to be Hadamard if $HH^T = nI$. I will demonstrate some bounds on the frustration index of Hadamard matrices and what this implies for the frustration index of more general matrices. (Received September 21, 2010)

1067-Z1-1508 **Praphat Xavier Fernandes*** (pxferna@emory.edu), Dept. of Math & CS, Emory University, 400 Dowman Dr., W401, Atlanta, GA 30322. *An Infinite Collection of Quasi-Isometrically Distinct Graph Braid Groups.*

We adapt techniques derived from the study of quasi-flats in Right Angled Artin Groups, and apply them to 2-dimensional Graph Braid Groups to show that the groups $PB_2(K_n)$ are quasi-isometrically distinct for all n. (Received September 21, 2010)

1067-Z1-1551 **Hilary Fletcher*** (hilary.deremigio@usma.edu), United States Military Academy, 646 Swift Road, West Point, NY 10996, **Alex Heidenberg** (alex.heidenberg@usma.edu), United States Military Academy, 646 Swift Road, West Point, NY 10996, and **Gerald Kobylski**, United States Military Academy, 646 Swift Road, West Point, NY 10996. *Improving College Mathematics Teaching Through Faculty Development.*

This past summer 15 mathematics faculty from several schools hosted an NSF funded and PREP sponsored workshop at the United States Military Academy titled "Improving College Mathematics Teaching Through Faculty Development." The primary focus of the workshop was to assist department leaders in developing effective faculty development programs that promote effective undergraduate mathematics education. In June of 2010 twenty-two participants from across the country attended the first workshop; these participants were accepted because of their strong interest in improving their own quality of teaching and the quality of teaching within their departments. We shared with them proven effective teaching strategies, instructional materials, and a program that they can utilize in faculty development sessions within their departments. In addition to outlining the content discussed during the workshop, during this session we will also discuss the feedback we received from our participants on how to make the next workshop even better. We will also discuss feedback from participants received six months after the workshop on how they have implemented ideas and strategies presented in the workshop. (Received September 21, 2010)

1067-Z1-1562 **Yang Xinyao*** (xywp8@mail.missouri.edu), 1133 Ashland Road, Apt 1612, Columbia, MO 65201. *Semigroup Operators in Cauchy Problems.*

This presentation examines the semigroup properties of operators in solving the Cauchy Equations. In the first part of my presentation, I will introduce the semigroup properties and the solution for classical Cauchy problems. In the second part of my presentation, I will deduce the method I use for some non-classical Cauchy problems. (Received September 21, 2010)

1067-Z1-1568 **Jody Sorensen***, Department of Mathematics, Augsburg College, 2211 Riverside Ave, Minneapolis, MN 55454. *The Real Story of Edward Lorenz.*

Mathematical lore describes how, in using a computer to model the weather, Edward Lorenz discovered sensitive dependence on initial conditions, one of the hallmarks of chaos. This behavior is often referred to as the butterfly effect. This then led to the Lorenz system of differential equations and its strange attractor. The truth, as always, is a little more complicated. In this talk we will clarify the truth behind the legend of the origins of chaos. (Received September 21, 2010)

1067-Z1-1572 **Violeta Vasilevska*** (Violeta.Vasilevska@uvu.edu), 800 West University Parkway, Orem, UT 84058. *Teaching Techniques and Activities that Encourage Proof Writing.* Preliminary report.

In this talk I will describe different methods/activities that I have used in upper level proof-based math classes that promote active in-class participation and encourage proof writing. I will discuss what did and did not work well with each of these methods/activities. In addition, students' feedback and useful suggestions will be shared. (Received September 21, 2010)

1067-Z1-1574 **Brandon Chabaud*** (chabaud@math.psu.edu), Pennsylvania State University, Mathematics Dept., 109 McAllister Bldg., University Park, PA 16802, and **Qiang Du**. *A mixed implicit-explicit multirate numerical scheme for time-dependent equations.*

We develop a multirate time integration method for systems of time-dependent equations that present two significantly different scales within the model. We use an iteration scheme to decouple the two time scales. At each iteration, we use an implicit Galerkin method to solve for the fast scale variable and an explicit method to solve for the slow variable. The error equation consists of a computable leading order term and a provably higher order expression. (Received September 21, 2010)

1067-Z1-1577 **Stephen A Sedory*** (kfsas00@tamuk.edu), 700 University Blvd., MSC 172 Dept. Of Mathematics, Kingsville, TX 78363, and **Sarjinder Singh** (kuss2008@tamuk.edu), 700 University Blvd., MSC 172 Dept. of Mathematics, Kingsville, TX 78363. *Estimation of Mode Using Auxiliary Information.*

In this paper, we propose a naive estimator, ratio estimator and difference estimator of the mode of a study variable by using the known mode of an auxiliary variable. The asymptotic properties of the proposed estimators are studied analytically as well as empirically for different situations. The proper use of auxiliary information is found to result in efficient ratio and difference estimators than the naive estimator. (Received September 21, 2010)

1067-Z1-1601 **William Benjamin Grilliette*** (s-wgrilli1@math.unl.edu), 550 N 26th St #20, Lincoln, NE 68503. *A New View of Presentation Theory for C*-algebras.*

In this talk, I offer an alternative presentation theory for C*-algebras with applicability to various other normed structures. Specifically, the set of generators is equipped with a nonnegative-valued function which ensures existence of a C*-algebra for the presentation. This modification allows clear definitions of a "relation" for generators of a C*-algebra and utilization of classical algebraic tools, such as Tietze transformations.

Further, I will demonstrate a behavior alien to algebraic presentation theory, yielding a bifurcation theory for isomorphism classes. As an example, I will discuss the universal C*-algebra of an invertible element, given by the presentation

$$\langle (x,t),(y,s) | xy = yx = 1 \rangle_{\mathbf{1C^*}},$$

where $t, s \geq 0$. The isomorphism classes which arise depend on a numeric condition on the product ts. If $ts = 1$, the algebra is $C(\mathbb{T})$. If $ts > 1$, the algebra is $C[0,1] *_{\mathbb{C}} C(\mathbb{T})$, the free product with amalgamation along the scalars. (Received September 21, 2010)

1067-Z1-1623 **Shadiyah Amani Mangru*** (smangru@gmu.edu), Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030. *Investigations in Linear Algebra and Combinatorics related to Biclique Decompositions of Graphs.*

We formulate five new propositions related to the Graham-Pollak Theorem. The first four illuminate properties of both biclique edge covers of the edge set of K_n, and nullspace basis vectors of a matrix representation of such covers. These four propositions motivate the recursively-defined sparse null space basis we present, as proposition five, for a particular subset of matrices of interest in Algebraic Graph Theory. (Received September 22, 2010)

1067-Z1-1635 **David Clark*** (dcclark@mtu.edu), Department of Mathematics, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931. *Using Steiner designs to construct entanglement-assisted quantum error-correcting codes.*

Entanglement-assisted quantum error-correcting codes (EAQECCs) are a newly discovered category of quantum codes. Among other benefits, EAQECCs can be created from *any* classical binary code, which is a significant advantage over the more common stabilizer quantum codes. We show how EAQECCs and block designs are fundamentally connected, and present a general method for constructing EAQECCs which is based on Steiner designs. This method creates infinite classes of EAQECCs with many desirable properties, including efficient decoding algorithms and very low error rates. (Received September 21, 2010)

1067-Z1-1636 **Osama H Taani*** (osama@nmsu.edu), 1011 Wooten Dr, Las Cruces, NM 88001. *Al-Kashi's Key to Arithmetic: Its Context, Contents, and Educational Impact Up Through the Ottoman Empire.* Preliminary report.

I will discuss the history of Giyath al-Din Jamshid al-Kashi's Key to Arithmetic, an encyclopedic Arabic mathematics textbook from the fifteenth century. While historical Islamic sources from the eighth to the twelfth century are rich in biographical information, especially of scientists, that is not the case for those from the fourteenth and the fifteenth century (al-Kashi's lifetime). The information about al-Kashi is scarce, scattered, and controversial. My data will come from my research into al-Kashi's own introductions to several of his books and also from some of his actual texts (such as his writings in mathematics and astronomy and his letters to his father), as well as some Arabic and English sources (I am translating parts of the Key to Arithmetic into English). I will discuss al-Kashi's life and achievement. I will also discuss the contents of the Key to Arithmetic (only small parts of which have up until now been translated into English), its historical context, and its impact on Medieval Islamic education including the Persian and Ottoman empires and Europe, from its birth up through the nineteenth century. (Received September 22, 2010)

1067-Z1-1642 **Robert L. Sachs*** (rsachs@gmu.edu), MSN 3F2, Department of Mathematical Sciences, George Mason University, Fairfax, VA 22030. *An investigation of student discovery of the concept of eigenvector in the context of 2-D linear vector fields.* Preliminary report.

Students in a multivariable calculus course were given an experimental environment depicting 2-D linear vector fields given by a symmetric matrix with adjustable coefficients. The aim was to see if the concept of eigenvector emerged from their investigations. (Received September 21, 2010)

1067-Z1-1649 **Jana R. Talley*** (jana.r.talley@jsums.edu), Just Science Hall, 242, 1400 J. R. Lynch St., Jackson, MS 39217. *Calculus Instructors' Responses to Prior Knowledge Errors.*

The ease with which a student learns a mathematical concept often depends on that student's knowledge base. Nevertheless, students often find themselves in classes for which their understandings of prerequisite skills are insufficient. Particularly in calculus, it is imperative that these prior knowledge deficiencies which hinder understanding be identified and examined. Who better to characterize these prerequisite errors that calculus students make than calculus instructors? This study investigates the views that Calculus instructors hold concerning prior knowledge. The term prior knowledge is operationalized as any skill or understanding that a student needs to successfully navigate through a Calculus I course. This study also attempts to begin clarifying the types of prerequisite skills that instructors deem critical in the rigorous study of calculus. A two part qualitative study consisting of student exams and instructor interviews was employed to examine how instructors approach prior knowledge mistakes when they are evaluating students. Analysis of these interviews revealed that calculus instructors agree that algebra and trigonometry are essential components of prior knowledge within a calculus course. (Received September 21, 2010)

1067-Z1-1661 **Mohamed Allali*** (allali@chapman.edu), 545 W. Palm Ave, Orange, CA 92866.
Application of a chaotic map to digital images.

Processing digital images can put, in some cases, mathematical ideas in an exciting new light. In this talk, I will show how calculating the period of a particular chaotic map can make it more visual and interesting for instructors and students in a linear algebra or number theory course. (Received September 21, 2010)

1067-Z1-1685 **J Mealy*** (jmealy@austincollege.edu), Austin College, Suite 61560, 900 North Grand Avenue, Sherman, TX 75090, and **Gregory Koch**. *Minimizing networks in Snell Geometry; the Snell-Steiner criterion.*

Further results in the category, Snell Geometry. (See various Snell Geometry abstracts from MathFests 2008–2010.) Recall that a Snell Geometry is a system consisting entirely of regions of locally constant curvature, wherein Snell's Law (of optics) is in play across the boundaries between these regions of constant curvature (but which have different "indices of refraction", n). After a few general remarks about this category, we report on recent work on minimizing networks in Snell systems (where all regions have zero curvature, but different values of n.) Here, both the Snell dynamic, as well as the Steiner minimizing tree configuration, are in play. Software modeling both of these phenomena has been developed and used to investigate these networks; this will be displayed. Of particular note, we are able to render a large set of non-classical Steiner point configurations. We discuss a criterion that was subsequently derived which characterizes these non-classical configurations, and further which subsumes both Snell's Law and the classical Steiner configuration. Some discussion of this dynamic within yet more complex Snell systems will be included. (Received September 21, 2010)

1067-Z1-1702 **Pedro Tradacete*** (tradacete@ub.edu), Dep. of Applied Mathematics and Analysis, University of Barcelona, Gran Via de les Corts Catalanes 585, 08007 Barcelona, Spain.
Positive operators on Banach lattices and domination properties.

Let us consider the following problems concerning operators between Banach lattices:

Domination problem: Let $0 \leq S \leq T : E \to F$. Under which conditions on E and F does S satisfy property (P) provided T satisfies (P)?

Power problem: Let $0 \leq S \leq T : E \to E$. When is there $n \in \mathbb{N}$ such that if T satisfies (P), then R^n also satisfies (P)?

A classical result of Dodds-Fremlin asserts that for $(P) =$"being compact", the first problem has a positive answer when E^* and F are order continuous and the second problem is solved for $n = 3$ (both being optimal). We will present several recent results for other properties such as Banach-Saks property [FT], strict singularity [FHT] and summability [PST].

REFERENCES:

[FHT] J. Flores, F. L. Hernandez, P. Tradacete. Powers of operators dominated by strictly singular operators *Quart. J. Math. Oxford* 59 (2008), 321-334.

[FT] J. Flores, P. Tradacete. Factorization and domination of positive Banach-Saks operators *Studia Math.* 189 (2008), 91-101.

[PST] C. Palazuelos, E. A. Sanchez-Perez, P. Tradacete. Maurey-Rosenthal factorization for p-summing operators and Dodds-Fremlin domination. (preprint) (Received September 21, 2010)

1067-Z1-1728 **Vincent Coll**, **Jeff Dodd** and **Michael Harrison*** (mah5044@gmail.com). *Archimedean Hypersurfaces.*

We develop a new class of hypersurfaces in n-dimensional Euclidean space which are defined by a single function and contain hypersurfaces of revolution as a proper subclass. These hypersurfaces are Archimedean in a sense suggested by Rudin in that they satisfy an equizonal type property of a sort well-known to hold for the sphere; that the surface area of a zone between two parallel planes depends only on the distance between the planes. The analogous property for hypersurfaces of revolution in higher dimensional Euclidean spaces has been investigated by the first two authors, where it was shown that for each $n \geq 2$, there is just one smooth n-dimensional hypersurface of revolution in $(n+1)$-dimensional Euclidean space that satisfies the equal area zones property. These hypersurfaces of revolution are called equizonal n-ovaloids and generalize the sphere in a previously undiscovered fashion. Making use of these ovaloids, we develop new Archimedean Hypersurfaces, and though not necessarily of revolution, they maintain interesting equizonal type properties. Using special functions, these objects can be fully mensurated. (Received September 21, 2010)

1067-Z1-1737 **David Offner*** (offnerde@westminster.edu), Department of Math and CS, Westminster College, New Wilmington, PA 16172. *Packing the hypercube.*

Let G be a subgraph of the n-dimensional hypercube Q_n. We consider two problems: First, is it possible to cover all vertices of Q_n using vertex-disjoint copies of G? Second, is it possible to cover all edges of Q_n using edge-disjoint copies of G? In the late 80's, Stout announced that for all G, and for n sufficiently large, it is possible to cover any given proportion $\alpha < 1$ of the vertices of Q_n, and conjectured that the same is true for edges. We will present a proof of this conjecture which uses as its main tool the Rödl nibble. (Received September 21, 2010)

1067-Z1-1741 **Alejandra Sánchez*** (asanchezva@gmail.com), Kr. 102 B. No. 148-40 Casa 65., Urbanización Campiña de Refous, Bogotá, 38007, Colombia. *Convexity Adjustment in the Valuation of the Financial Derivatives.* Preliminary report.

In the valuation of financial derivatives whose payoff depend on the interest rates it is necessary to know the role of probability distribution of the rates at certain moments in time. Sometimes these moments are not the most fortunate for the calculation because with regard to the extent of associated probability may not be a Martingale measure free of risk. However, it is possible to find a Martingale measure and the rate with regard to it, and then adjust the value to get the desired valuation. This setting is the well-known convexity adjustment (or convexity correction). A recent problem in financial mathematics is the interpretation from the mathematical point of view in order to obtain analytical expression for its assessment. I will present some attempts and estimates in that direction. (Received September 21, 2010)

1067-Z1-1744 **Mikil Foss** and **Joe Geisbauer*** (s-jgeisba1@math.unl.edu), University of Nebraska-Lincoln, 203 Avery Hall, P.O. Box 880130, Lincoln, NE 68588-0130. *Partial Regularity for Parabolic Systems with Subquadratic Growth.* Preliminary report.

We establish the partial Hölder continuity of solutions to quasilinear parabolic systems with subquadratic growth. The major feature of the result is establishing the partial regularity while only requiring the coefficients for the system to be continuous. To establish the result, we use DiBenedetto's intrinsic scaling to prove a decay estimate for a normalized excess functional. This decay estimate provides a control on the type of singularities that the spatial gradient of the solution might exhibit, which yields the partial continuity of the solution. (Received September 22, 2010)

1067-Z1-1754 **Jason E Miller*** (millerj@truman.edu), 100 E Normal St, Kirksville, MO 63501. *Report on the NSF PRISM project at Truman State University.* Preliminary report.

Truman State University continues its efforts to broaden participation in STEM degree programs through its 'Scientists Prepared, Enriched, Challenged Through Research-based Activities' program (NSF PRISM #0928013). This program has three components. The first studies the effect of a summer jumpstart (or bridge) program for incoming first-year students with a high level of enthusiasm for STEM degree programs but a low level of preparation. The second studies the effect of cohort-based integrative introduction to STEM for high-ability incoming first-year students who have a low level of interest in STEM. We are measuring rates of persistence in STEM for each group. The third component of the program aims to re-engineer the pipeline of students from 2-year programs to 4-year STEM programs with three high-quality community college partners. This talk will convey preliminary results of our work. (Received September 21, 2010)

1067-Z1-1756 **Larry Wayne Lewis*** (llewis@spalding.edu), Spalding University, 845 South 3rd Street, Louisville, KY 40203. *An Action Research Report: Does the Ability to Purchase a Week's Worth of Groceries for under 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 perhaps 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 underprepared students. Results from this study will be shared. (Received September 21, 2010)

1067-Z1-1760 **Emese Lipcsey-Magyar***, ealipcse@ncsu.edu, and **Ava Hamilton**, **Rachel Roe-Dale**, **Kimberley Frederick** and **Katherine Roguski**. *Modeling Time-Dependent Electroosmotic Flow.* Preliminary report.

Capillary Electrophoresis (CE) is a new analytical chemistry technique that is faster, requires less sample, and generates less chemical waste than conventional methods. CE separations have a higher separation resolution than current technology and would therefore improve pathogen screenings and other blood tests. One of the major downfalls of CE is the presence of irreproducible Electroosmotic Flow (EOF). EOF is the velocity of liquid through a glass capillary when an external potential is applied. In order to predict trends in EOF, a mathematical model is needed. A biexponential function, the sum of two exponential terms, is predicted to best model EOF during discontinuous buffer conditions. Several data sets were collected and analyzed to verify this prediction. The presentation will highlight our methods of analysis including parameter estimation and residual analysis. (Received September 21, 2010)

1067-Z1-1763 **David Crombecque*** (dcrombec@gettysburg.edu). *Teaching a first semester Calculus class entirely through Inquiry Based Learning.* Preliminary report.

In this report, we will look at the benefits, challenges and outcomes for students engaged in a first semester of College Calculus taught exclusively through Inquiry Based Learning (inspired by Moore's method). This class was taught during Fall 2010 to a Freshman class. The content focused on the creation of the theory of calculus and was proof-intensive. The entire class time was devoted to students presentations and had very little to no lecturing components. (Received September 21, 2010)

1067-Z1-1795 **Lee J Stemkoski*** (stemkoski@adelphi.edu), 211 Post Hall, Adelphi University, 1 South Ave., Garden City, NY 11530. *Applications of Calculus to Game Theory: The Prisoners' Dilemma.*

The Prisoners' Dilemma is a classic example of a two-player interaction that highlights the conflict between altruistic and self-centered behaviors. We assume that the players will interact repeatedly and that previous outcomes influence the decisions of each player. Given this scenario, techniques from calculus may be used to analyze strategies and determine an optimal sequence of decisions. In this talk, we present a teaching module centered around applications of calculus to the Prisoners' Dilemma; the module may be used for courses in differential, integral, and multivariable calculus. (Received September 21, 2010)

1067-Z1-1807 **Amy Mihnea*** (amihnea@fau.edu). *Patterns for Permutations with Fixed Points.*

We apply a pattern-recognition algorithm to the problem of counting permutations with certain properties, starting with the standard inclusion-exclusion formula for calculating the number of derangements of order n. At the intermediate steps, the number of some subsets of permutations with k fixed points, k from 1 to n, is considered. We find the distribution of the differences between adjacent elements for two of these subsets, by connecting each of them to a set of matrices, which we then analyze in order to find patterns. We divide these matrices into families and calculate the final distribution as a sum of intermediate distributions. (Received September 21, 2010)

1067-Z1-1828 **Kumnit Nong*** (knong@gmu.edu), 4400 University Dr, Fairfax, VA 22030, and **Daniel M Anderson** (danders1@gmu.edu), George Mason University, Department of Mathematical Sciences, 4400 University Dr, Fairfax, VA 22030. *Thin Film Evolution over a Thin porous Layer: Modeling a Tear Film on a Contact Lens.*

We examine a mathematical model describing the behavior of the precontact lens tear film of a human eye. Our work examines the effect of contact lens thickness and lens permeability on the film dynamics. Also investigated are gravitational effects and the effects of different slip models at the fluid-lens interface. A mathematical model for the evolution of the tear film is derived using a lubrication approximation applied to the hydrodynamic equations of motion in the fluid film and the porous layer. The evolution equation is solved numerically, and the effects of various parameters on the rupture of the thin film are studied. We find that increasing the lens thickness, permeability, and slip all contribute to an increase in the film thinning rate, although for parameter values typical for contact lens wear, these modifications are minor. Gravity plays a role similar to that for tear films in the absence of a contact lens. The presence of the contact lens does, however, fundamentally change the nature of the rupture dynamics as the inclusion of the porous lens leads to rupture in finite time rather than infinite time.interaction. (Received September 21, 2010)

1067-Z1-1834 **Julie A. Belock*** (jbelock@salemstate.edu), Salem State University, 352 Lafayette St., Salem, MA 01970. *Conditional probability via topics in social justice.* Preliminary report.

In the mid-1990s a New Jersey racial profiling case alleged that black drivers were pulled over by state troopers and searched at a higher rate than were drivers in general. I have developed activities around this case and other situations involving social justice to strengthen understanding of conditional probability for statistics students of all levels. (Received September 22, 2010)

1067-Z1-1838 **William Pachas-Flores*** (wpachas@uci.edu), 340 Rowland Hall, University of California, Irvine, Irvine, CA 92697, and **Michael Cranston**, Irvine, CA 92697. *Central Limit Theorem for Stochastic Flows.* Preliminary report.

The spread of a body of passive tracers within or on the surface of a turbulent fluid is of great interest to the various branches of science. Examples of this include an oil slick on the surface the ocean, a mass of plankton, or a pollutant in the atmosphere. The first two will be dispersed by the random current of the ocean, while the dispersion of the last one will depend on random atmospheric patterns. Since turbulent flows are characterized by chaotic and stochastic changes, it is reasonable to approximate them by stochastic flows. The advantage of using stochastic flows to model turbulent actions is the availability of the tools of stochastic differential equations.

We're interested in establishing an a.s asymptotic Central Limit theorem for the distribution of the evolution of the two point motion under the isotropic Brownian flow. We also interested at the invariance principle, independence of the one point distributions, and a CLT for the distributions of the one point motions for non-isotropic stochastic flows. An a.s asymptotic CLT for the one point motion distribution under the action of a standard isotropic Brownian flow has been established by M. Cranston and Yves Le Jan (2009). (Received September 22, 2010)

1067-Z1-1844 **luc patry*** (luc.patry@gmail.com), Mathematics Department, University of Arkansas at Pine Bluff, 1200 N University Drive, Pine Bluff, AR 71601. *"Rigidity" and Language of Fundamental Groups of Manifolds.* Preliminary report.

I intend to describe how language theory can be used to express the logical complexity of Poincarre groups of Riemannian Manifolds (spaces that locally resemble $\mathbb{R}^n$.) In particular, I intend to show that regular languages (the simplest of languages in Chomsky's language hierarchy theory) can "naturally" express structures of tilings of 2-manifolds (surfaces.) This talk should be accessible to anybody. (Received September 22, 2010)

1067-Z1-1864 **Samad Hedayat** and **Wei Zheng*** (wzheng8@uic.edu), 938 w. 32nd pl. #3 R, chicago, IL 60608. *Optimal and Efficient Crossover Designs for Test-Control Study When Subject Effects are Random.*

We study crossover designs based on the criteria of A- and MV- optimality under the model with random subject effects, for the purpose of comparing several test treatments with a standard control treatment. Optimal and efficient designs are proposed, and their efficiencies are also evaluated. A family of totally balanced test-control incomplete crossover designs based on a function of the ratio of the subject effect variance to the error variance are shown to be highly efficient and robust. The results have interesting connections with those in Hedayat and Yang (2005) and Hedayat, Stufken, and Yang (2006). (Received September 22, 2010)

1067-Z1-1869 **Michael D Miner*** (jcmhs77@aol.com), 65 Edenbrook Dr., Hampton, VA 23666. *Utilizing Web-Based Mathematical Resources in Teaching Nontraditional Undergraduate Students in Online Learning Environments.*

The challenges facing delivery of a College Algebra class to nontraditional undergraduate students in nontraditional higher education programs are especially pronounced when the environment for learning is online. Outside of entering the program with varying degrees of mathematical competencies, students are more than likely to encounter different styles and techniques of learning mathematical concepts than previously encountered in prior mathematical educational endeavors. However, along with this alternative structure, scores of web-based algebraic resources exist and are readily available to support learning and understanding of course related instructional materials. Web-based algebraic resources range from the elementary and basic techniques to extremely complex theoretical algebraic structures. However, the key for the online instructor/facilitator is to not only balance the appropriate number and complexity of resources but also to insure that students effectively use them for understanding the algebraic concepts presented to them. This research considers how online algebraic resources are introduced in the online learning environment and which method is the most effective strategy to support teaching and learning of College Algebra. (Received September 22, 2010)

1067-Z1-1879 **Tolga Karayayla*** (tkarayay@math.upenn.edu). *Classification of Automorphism Groups of Rational Elliptic Surfaces.* Preliminary report.

In this work the classification given indicates the possible automorphism groups of relatively minimal rational elliptic surfaces according to the configuration of singular fibers on the surface. A relatively minimal rational elliptic surface is equivalent to the blow-up of the projective plane at the 9 base points of a pencil of cubics whose generic element is a smooth cubic. This pencil gives a map to the projective line. The generic fiber of this map is a smooth elliptic curve but there are also singular fibers. The configuration of these singular fibers plays an important role in determining the automorphism group of the surface. The set of sections of the above map is a group called the Mordell-Weil group of the surface, which embeds in the automorphism group of the surface. The Mordell-Weil group is completely determined by the configuration of singular fibers on the elliptic surface as shown by Oguiso and Shioda. If one considers the subgroup of automorphisms preserving the zero section of the surface setwise, then the automorphism group is the semi-direct product of the Mordell-Weil group and this subgroup. This subgroup is a group of order at most 24 and I will present how to determine it from the configuration of singular fibers on the rational elliptic surface. (Received September 22, 2010)

1067-Z1-1882 **T Hudson Harper*** (tharper07@gmail.com), 1527 Highland Gate Point, Hoover, AL 35244. *New Ramanujan congruences for partition related eta-quotients.*

In a 1919 paper, Ramanujan proved his three eponymous congruences for the integer partition function using identities of q-series. Since then, combinatorial identities, properties of Eisenstein series, and other methods have been employed to prove these results. In 1981, Serre proved there exists a finite list of lacunary powers of the eta function. From these lacunary functions, Ramanujan's congruences can be proven in a new way. In this talk I will demonstrate how congruences, similar to Ramanujan's, of general partition functions can be constructed and proven using the lacunarity of specific eta-quotients. I will also discuss questions analogous to those for the integer partition function like the completeness of the classification of Ramanujan congruences. (Received September 22, 2010)

1067-Z1-1891 **Gregory V. Bard*** (bard@fordham.edu), Dept of Math, John Mulcahey Hall, Fordham University, The Bronx, NY 10458. *Exploring Game Theory with SAGE, the open-source competitor to Maple, Mathematica, Matlab and MAGMA.*

Game theory can be an exciting and refreshing topic for students of several levels, with applications in economics, military science, and decision making. When there are two players, the equations are degree one, and thus it is a popular topic to study the applications of linear programming and probability. The SAGE computer algebra package is the open-source competitor to Maple, Matlab, Mathematica, and MAGMA. This talk will show how SAGE can be used to explore game theory, and assist in the computation of Nash Equilibria, as well as find strictly- and weakly-dominated strategies.

The focus will be on the three bridges game, where an escaped convict desires to elude capture by crossing one of three bridges of varying degrees of structural integrity, balancing the need to avoid capture with the risk of the bridge collapsing.

The talk will be entirely comprehensible to those without any knowledge of game theory. (Received September 22, 2010)

1067-Z1-1893 **Kyle Riley*** (Kyle.Riley@sdsmt.edu), Dept. Math & Computer Science, SDSMT, 501 East Saint Joseph Street, Rapid City, SD 57701. *Redesign of Calculus 2.* Preliminary report.

The design of a traditional second semester calculus class typically involves the development of exponentials and logarithms, inverse trigonometric functions, hyperbolic functions, techniques of integration, L'Hôpital's Rule, infinite series, parametric functions, and maybe some coverage related to conic sections. If all the students in our calculus sections were mathematics majors then this course design would be suitable for their major, but the simple fact that the vast majority of our students are engineering and science majors has prompted us to consider a different design for our calculus 2. This talk will present a pilot project that attempts to modify calculus 2 to provide content that appears to be desperately needed by our students very early in their academic programs. (Received September 22, 2010)

1067-Z1-1897 **Chris Lacke*** (lacke@rowan.edu), Mathematics Department, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028. *Developing A Successful Actuarial Study Group Without Having A Program In Actuarial Science.*

A career in actuarial science has consistently ranked at or near the top in overall job satisfaction. As a result, many students are curious in the possibilities, at least until they find out how much math is involved. As a result, many undergraduate schools lack the necessary core student group to be able to offer a substantial group of courses in the field. Nevertheless, faculty members who are interested in the field often find great satisfaction in working with the small, but dedicated group of students who have the talent and desire to pursue this career.

In this talk, I shall discuss some of the strategies that have helped our annual study group to succeed, ideas about using common existing curricula to help students work toward later exams and VEE credits, and how to keep students on the right track when that first exam grade ends up being a 5. (Received September 22, 2010)

1067-Z1-1898 **Gregory M Johnson*** (greggo@math.cmu.edu), Department of Mathematical Sciences, Wean Hall 8122, Carnegie Mellon University, Pittsburgh, PA 15213, and **Christopher S Shaw** (cshaw@colum.edu), Department of Science & Mathematics, Columbia College, 600 S. Michigan Ave., Chicago, IL 60605. *The war on apathy in a terminal statistics course: Motivating definitions from day one.* Preliminary report.

A terminal mathematics sequence often serves as a net for students uninterested in pursuing mathematical material beyond the point of rote memorization and plug-and-play algorithms, all to be forgotten after the final exam. The pedagogical evidence points toward motivating definitions and concepts through interactive learning as a method to combat this problem, yet such exercises are difficult to capture in the introductory exposition of a textbook. We present several efficient approaches for introducing salient statistical concepts in class, and discuss how a five-minute anonymous survey can generate data whose pedagogical properties are engineered to illustrate most of the key definitions that go into a typical first week of classes. (Received September 22, 2010)

1067-Z1-1910 **Eugene C. Boman*** (ecb5@psu.edu). *Fixing Fluxions: Benjamin Robins' response to Berkeley's "The Analyst".*

In a treatise titled "The Analyst" published in 1734 Bishop George Berkeley attacked the foundations of what we now call Calculus. The initial responses, from James Jurin and J. Walton were angry and antagonistic in tone, especially Jurin's.

Later, when cooler heads prevailed, several mathematicians attempted to present Newton's Method of Fluxions rigorously and to address the difficulties Berkeley had identified. One of the earliest was Benjamin Robins's "A Discourse Concerning the Nature and Certainty of Sir Isaac Newton's Method of Fluxions and of Prime and Ultimate Ratios". I will present and examine some key passages from Robins' treatise. (Received September 22, 2010)

1067-Z1-1923 **John F. Bukowski*** (bukowski@juniata.edu), Department of Mathematics, Juniata College, 1700 Moore Street, Huntingdon, PA 16652. *How Christiaan Huygens Tuned the Musical Scale.*

The tuning of the intervals in the musical scale has a long history dating back to the Pythagoreans. Several seventeenth-century mathematicians proposed different approaches to resolving the inherent difficulties in tuning the musical scale. We will see how Christiaan Huygens used logarithms to divide the octave into a 31-tone scale, and we will compare his tuning to other tunings of the scale. (Received September 22, 2010)

1067-Z1-1926 **Don K Krug*** (krugd@nku.edu), Department of Mathematics and Statistics, Northern Kentucky University, Nunn Drive, Highland Heights, KY 41099. *Teaching Introductory Computer Programming to Mathematics Majors with SAGE.*

For several years we have been teaching a computer science course geared to mathematics majors. This course has been taught using a computer algebra system as the programming environment. The goals are:

(1) to get students comfortable with a CAS so that they will willingly use it in their course work and be ready to use it in research projects
(2) to teach basic programming skills to allow students to migrate their skills to other programming environments with ease.

Originally taught using Mathematica, this course has recently been migrated to SAGE. In this talk I will give an overview of the course and point out some of the advantages and disadvantages of each CAS. (Received September 22, 2010)

1067-Z1-1935 **David Dennis** (david.dennis@earthlink.net), 4249 Cedar Dr., San Bernardino, CA 92407, and **Susan L. Addington*** (saddingt@csusb.edu), Math Dept., CSUSB, 5500 University Pkwy., San Bernardino, CA 92407. *Euler Drives the Leibniz Machine and Takes the Log and Trig Functions out for a Spin on the Complex Numbers.*

The object of Leibniz's calculus was to create a machine syntax, based on tables, capable of computing all known geometric quantities (tangents, areas, arclengths, etc.). Despite success, his calculus produced no major new results, and was lapsing into obscurity, until Euler used the system and its notation to resolve the issue of how to define the logarithms of negative numbers. He then produced all of the unique definitions of transcendental functions over the complex numbers. Startlingly beautiful geometric mappings result. Now, with the aid of computers, every student can explore this realm without being "analysis incarnate" (Euler's nickname). Using Newton's Binomial Series within a Leibnizian notation, Euler's textbooks persuaded everyone to agree to his definitions. The worldwide spread of Euler's curriculum eventually completed the paradigm shift from mathematics as geometry to mathematics as algebra.

The details of this story can be found at Mathematical Intentions, An Ethnomathematical History of Secondary Mathematics (Algebra I-Calculus), http://www.quadrivium.info. (Received September 22, 2010)

1067-Z1-1943 **Bryan Nankervis*** (bn10@txstate.edu), 601 University Drive, San Marcos, TX 78666.
Economic-Based Affirmative Action in College Admissions.

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 first review the effects of the "Top Ten Percent Rule" on admissions in Texas since the Hopwood decision. Then it will provide an alternative plan that will create greater socioeconomic and racial diversity, strengthen academic standards, and increase graduation rates at more selective public universities. (Received September 22, 2010)

1067-Z1-1945 **Dawit Gezahegn Tadesse*** (dgt0001@auburn.edu), Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849-5310, **Xuhua Liu** (xzl0002@auburn.edu), Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849-5310, and **Tin-Yau Tam** (tamtiny@auburn.edu), Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849-5310. *A range associated with skew symmetric matrix.*

We study the range

$$S(A) := \{x^T Ay : x, y \text{ are orthonormal in } \mathbb{R}^n\},$$

where A is an $n \times n$ complex skew symmetric matrix. It is a compact convex set. Power inequality $s(A^{2k+1}) \leq s^{2k+1}(A)$, $k \in \mathbb{N}$, for the radius $s(A) := \max_{\xi \in S(A)} |\xi|$ is proved. When $n = 3, 4, 5, 6$, relations between $S(A)$ and the classical numerical range and the k-numerical range are given. (Received September 22, 2010)

1067-Z1-1947 **Kenneth J Bernard*** (kbernard@vsu.edu), Dr. Kenneth J Bernard, Dept of Math & Computer Science, PO Box 9068, Petersburg, VA 23806. *Improving Student Success on PRAXIS II (Mathematical Content).*

At Virginia State University there has been an effort over the past several years to improve the percentage of students successfully passing the PRAXIS II (mathematical Content, 0061) requirement in order to student teach and complete the secondary mathematics teaching program. In Virginia and many states, a student is not allowed to enroll in Student Teaching until PRAXIS II has been passed. When a student is unsuccessful in passing PRAXIS II, they are taken out of the pipeline to supply future secondary teachers of mathematics and may be required to transfer out of a Teacher Education program into other programs during their senior year of studies. A Problem Solving Seminar course for junior majors was created several years ago, but has not been wholly successful. Other options are being explored to assist student be more successful on the examination. Several of these options will be explored and plans for a departmental mentoring program will be discussed. (Received September 22, 2010)

1067-Z1-1949 **Laurie Lenz*** (Laurie.Lenz@marymount.edu), Marymount University, 2807 N. Glebe Rd., Arlington, VA 22207. *An Experiment in Student Centered Learning.* Preliminary report.

This semester I decided experiment with student centered learning. I designed activities for the entire semester in Discrete Mathematics, a second year course for mathematics and computer science majors. The students worked on the activities in groups each class meeting and presented their findings and results to each other. In this talk I will discuss the development process for the activities and the reactions of the students to the course. I will also attempt to compare student outcomes in this experimental version of the course with outcomes in the traditional version of the course. (Received September 22, 2010)

1067-Z1-1955 **James R Choike*** (choike@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, and **Cos Fi** and **Vytas Laitusis**. *Formative Assessment: A Key Strategy for Calculus Teaching.* Preliminary report.

This session will describe a strategy for delivering online professional development to AP Calculus teachers, featuring written and video materials. Professional development (PD) is based on supplemental calculus lessons that emphasize a two-part pedagogical guiding principle: (1) "thinking about mathematics in the classroom" is a key to student learning; and (2) "student communication in the classroom" is equally important, since communication not only confirms student thinking, but also provides fertile instructional feedback that informs what students know and how they know it. This session will discuss: (1) the pedagogy of "student thinking" and "student communication of thinking" in the classroom; (2) the instructional design of the PD materials for implementing a "student thinking" pedagogy; (3) the relationship of this featured pedagogy to formative assessment as a strategy for improving student learning; and (4) a framework for implementing formative assessment that connects to developing "pedagogical content knowledge" (PCK) for calculus. (Received September 22, 2010)

1067-Z1-1957 **Mike Long*** (malong@ship.edu), 11 Independence Drive, Shippensburg, PA 17257. *Platonic Solid Puzzles and Patterns.*

Unique puzzles emerge when the decompositions of Platonic Solids into unit Platonic Solids, either of the same solid or combinations of the same and other solids, are considered. Even more interesting are the numeric sequences, primarily polygonal numbers or multiples of them, which emerge when counting the unit Platonic Solids. Some more unique puzzles and surprising sequences are found when other solids are decomposed into unit Platonic Solids as mentioned above. These decomposition patterns are made more convincing when Polydrons are used as visual aids. (Received September 22, 2010)

1067-Z1-1982 **Richard H Stout*** (richard.stout@gordon.edu), Department of Mathematics, Gordon College, Wenham, MA 01984. *Mr. Peacock's Calculus Text of 1820 and Its Place in Calculus Reform at Cambridge.*

The Cambridge mathematician George Peacock is perhaps best known for his work in changing the perception of the nature of algebra. However, in 1820, ten years before his algebra text appeared, Peacock published a work on calculus, A Collection of Examples of the Applications of the Differential and Integral Calculus. In this talk we'll consider how this book fit into the reform efforts of the student-led Analytical Society, founded in 1812, and also look at several examples from the text that help illustrate the nature of this early calculus reform movement at Cambridge. (Received September 22, 2010)

1067-Z1-1985 **Kara L. Maki*** (makia001@ima.umn.edu), University of Minnesota, 114 Lind Hall, 207 Church Street S.E., Minneapolis, MN 55455, and **Satish Kumar** (kumar@cems.umn.edu), Dept of Chemical Eng and Materials Science, 151 Amundson Hall, 412 Washington Ave S.E., Minneapolis, MN 55455. *Drying Droplets of Colloidal Suspensions: Role of Rheology.* Preliminary report.

When a coffee droplet dries on a countertop, a dark ring of coffee solute is left behind, a phenomenon often referred to as "the coffee ring effect". The droplet initially has a uniform distribution of solute, but flow inside the droplet carries the solute to the droplet edges as evaporation occurs. A closely related yet less-well-explored phenomenon is the formation of a layer of particles, or skin, at the surface of the droplet. This phenomenon is highly relevant to the coating and drying of colloidal suspensions, and the goal of this work is to investigate the underlying mechanisms.

We consider the drying of a thin axisymmetric droplet of a colloidal suspension on a horizontal substrate. The fluid motion is described by applying the lubrication approximation, and the transport of the particles is described using the full convection-diffusion equation. The particles are assumed to influence the rheology of the droplet through their effect on the suspension viscosity. The highly coupled governing system of equations is simulated using a finite-difference scheme based on a moving overset grid method. Preliminary findings along with future plans will be discussed. (Received September 22, 2010)

1067-Z1-1986 **Johann A. Thiel*** (jthiel2@math.uiuc.edu). *The behavior of Conway's RATS sequences.*

Given an integer base b and a positive integer n, let $\overline{n}$ be the integer obtained by reversing the base b digits of n, and let n' denote the integer obtained by sorting the base b digits of n in increasing order. Conway's RATS (Reverse-Add-Then-Sort) sequences in base b are the sequences generated by iterating the function $f(n) = (n+\overline{n})'$, starting from some initial number n_0. We discuss conjectures and results on the behavior of these sequences. (Received September 22, 2010)

1067-Z1-1990 **Josip Derado*** (jderado@kennesaw.edu), Dept. of Mathematics and Statistics, Kennesaw State University, 1000 Chastain Rd, Kennesaw, GA 30144. *How to teach college classes with a large diversity in students abilities and interest.*

A common problem we are facing in today's college environment is alarge diversity in students abilities to do mathematics and their interest in mathematics. The problem is the most prevalent in the entry level courses, like calculus. The student body is a mixture of students whose majors vary from math to biology or business. As a result the students ability and their interest differ significantly. For example, while the math students would like to see more proofs in the course, biology major would be more interested in pure computational aspects of the course. In the first year courses, the students ability and the knowledge and understanding of mathematics they brought from the high school varies significantly.

We developed the teaching method appropriate for the college settings which would assess the problem and allow an instructor to successfully adopt his teaching to accommodate the student body. The method is based on a differentiation of assignments according to students' individual progress throughout the course and their individual interest.

The paper presents the method and the analysis of the data obtained from the application of the method in the last 3 years at Kennesaw State University. (Received September 22, 2010)

1067-Z1-1992 **Jon Davidson*** (jdavidson@sscc.edu), Southern State Community College, 100 Hobart Drive, Hillsboro, OH 45133. *Non-existence of regular polygons in the Cartesian plane with vertices at integer coordinates, except for squares.*

Is it possible to create a regular polygon in the Cartesian plane such that all the vertices have integer coordinates? Except for squares, we shall show that no such polygons can exist. The mathematics required is pre-calculus level and thus the proof is quite understandable to the undergraduate. Furthermore, as a consequence, working this problem exposes a class of polynomials with coefficients from Pascal's triangle which have roots of $\tan(2\pi/n)$. (Received September 22, 2010)

1067-Z1-1999 **Serge C Ballif*** (ballifserge@gmail.com). *Conditions for Embedding a Partial Latin Square Inside a Latin Square of a Given Order.* Preliminary report.

We provide necessary and sufficient conditions for a latin square of order n to be embedded inside a latin square of order $n+k$. This builds upon the work of T. Evans who showed that each partial latin square of order n may be embedded inside a latin square of order t for each $t \geq 2n$. We also determine how many of the n^2 entries of a given latin square of order n can be preserved in (the upper left corner of) a latin square of order $n+k$. (Received September 22, 2010)

1067-Z1-2001 **Candace M. Schenk*** (schenk@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University, Binghamton, NY 13902-6000. *On the solution of the conjugacy problem of Thompson's group F.*

I will discuss the Salazar-Díaz solution to the conjugacy problem in V and how it relates to my research on the commutator subgroup of F. (Received September 22, 2010)

1067-Z1-2008 **George F. Sweeney*** (georgefsweeney@gmail.com). *Getting Back Home: Student Meaning-Making in Linear Algebra.*

The use of applications and realistic problems to introduce mathematical concepts is not new. However, the question of what gets learned from the problem situation to new and different problems that engage with similar mathematical material is still an issue widely discussed amongst mathematics educators. This study arises from an introductory linear algebra class at a southwestern research university, where students were introduced to an experientially real setting that served to give students an entry point into the basics of the system of vectors and vector equations. As members of the class worked on new problems stemming from the setting, they presented and discussed their conjectures and related those ideas to formal mathematics. During and after the presentation of this sequence, I conducted a series of focus group interviews to understand what meanings the classroom community developed for vectors and vector equations. In this talk, I show the ways that students utilized the language and imagery of the setting even in linear algebra problems not directly tied to the scenario. I demonstrate that these meanings reflected the shared experience of the members of this classroom as they strived to work within the setting and extend it to formal settings. (Received September 22, 2010)

1067-Z1-2018 **Kamuela E Yong*** (kyong@math.uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242, **Yi Li** (yli@math.uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242, and **Stephen Hendrix** (stephen-hendrix@uiowa.edu), Department of Biology, 143 Biology Building, Iowa City, IA 52242. *Modeling almond pollination by two interacting bee species with cross- and self-diffusion.*

California's almond industry is one of America's top agricultural exports valued at $1.9 billion per year. Successful production of almonds depends on the pollinator services of primarily honeybees, although pollination by wild bees is being investigated as an alternative because ofrecent problems with honeybees. We are modeling pollinator services of honey and wild bees, as well as their interactions in almond orchards. We use the Shigesada-Kawasaki-Teramoto model (1978) which describes the density of two species in a two-dimensional environment of variable favorableness with respect to intrinsic diffusions and interactions of species. We apply the model to almond pollination by wild and honey bees with environmental favorableness based on empirical data measuring the attractiveness of the canopy for honey and wild bees. Using the spectral-Galerkin method in a rectangular domain, we numerically solved the 2D nonlinear parabolic PDE and examine the result of varying the parameters. In addition, we will investigate the inverse problem using empirical data collected on bee density and behavioral observations on their interactions. We hope to determine what circumstances the presence of wild, solitary bees can increase the dispersion of honeybees, thus increasing pollination. (Received September 22, 2010)

1067-Z1-2019 **Matthew Willyard*** (mwillyar@math.fsu.edu), FSU Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306, and **David A. Kopriva**, FSU Mathematics, 208 Love Building, 1017 Academic Way, Tallahassee, FL 32306. *An Adaptive Spectral Element Method to Price American Options.* Preliminary report.

We price American options using a new adaptive spectral element method. We develop an adjoint-based global error estimator that determines where (de)refinement is needed. Then we use a work estimator to decide between h and p-(de)refinement. The result is an approximation with an error within prescribed tolerances solved on meshes that use far fewer nodes than the uniform mesh required for the same error level. (Received September 22, 2010)

1067-Z1-2024 **Matthew F Short*** (short@math.binghamton.edu), Department of Mathmatical Sciences, Binghamton University, Binghamton, NY 13902-6000. *Generalizations of Thompson's Group V.* Preliminary report.

I will give a short introduction to Thompson's Group V, demonstrate a generalization, and discuss my research with the group. (Received September 22, 2010)

1067-Z1-2032 **Mary E Allison*** (mallison@uwyo.edu), 360 N 9th street Apt. 102, Laramie, WY 82072. *Mean First Passage Times and the Kemeny Constant on Tree Networks.*

The mean first passage time from state i to state j denoted as $m_{i,j}$ of a finite regular ergodic Markov chain with n states is the expected number of time steps to reach state j for the first time given that chain was initially in state i. The Kemeny constant is sometimes defined as the average of all the mean first passage times $m_{i,j}$ such that $i = 1 \ldots n$ and $j = 1 \ldots n$. The mean first passage times and the Kemeny constant provide useful information about the short term behavior of the Markov chain. For a symmetric Markov chain defined on a graph G the Kemeny constant is related to the trace of the group inverse of a weighted Laplacian matrix for the graph, so known results pertaining to the group inverse of the Laplacian for trees allow us to generate formulas for the Kemeny constant on tree networks. (Received September 22, 2010)

1067-Z1-2033 **James A Jones*** (james.jones@usma.edu), Department of Mathematical Sciences, West Point, NY 10996, and **Elizabeth W Schott** (elizabeth.schott@usma.edu), **Stanley F Florkowski** (stanely.florkowski@usma.edu) and **Brian J Lunday** (brian.lunday@usma.edu). *Proactively Preventing Project Procrastination.* Preliminary report.

The ability to clearly communicate mathematical concepts and their application in writing is a fundamental skill to develop in undergraduate mathematicians. Although many curricula incorporate a written course project to assess the student's ability to relate the material to an audience, it is often treated as a large homework set, in that all of the work is done outside of class. This construct allows for procrastination by students whose work ethic (habits of mind) is not yet fully developed. In this talk, we discuss our application of a "project week" within various mathematics courses at our university. Setting aside new material, we dedicate time in- and out-of-class for formal interaction between the instructor and students in order to allow for them to (1) affect steady progress towards completion of their project; (2) increase their access to the instructor and, subsequently, feedback on their work to ensure it is mathematically sound, before beginning the written communication of their results; and (3) in the case of group projects, develop student's ability to form productive groups in a structured setting that allows them to produce quality and efficient group work outside of class. (Received September 22, 2010)

1067-Z1-2035 **Kate G McGivney*** (kgmcgi@ship.edu), 1871 Old Main Dr., Shippensburg University, Shippensburg, PA 17257. *A History of Math Seminar Course for Future Secondary Teachers.* Preliminary report.

In this talk I will discuss a seminar-style model that I implemented in my history of math course for an audience that was primarily future secondary mathematics teachers. A key goal of the course was to provide an opportunity for students to study historical topics while reviewing secondary school level mathematics. Strategies for getting students to become actively engaged in the readings and learning process will be shared. (Received September 22, 2010)

1067-Z1-2043 **J Kingsley Fink*** (j.fink@usma.edu), Department of Mathematical Sciences, United States Military Academy, 646 Swift Road, West Point, NY 10996. *Project Group Student Selection: Using Prior Academic Performance to Improve Group Dynamics.*

Undergraduate courses at the U.S. Military Academy often require group projects. In MA206, Probability & Statistics, two group projects entail approximately 25% of the Cadet's course grade. This large portion dedicated to group work suggests careful consideration be taken in how Cadets are grouped for these projects. A simple poll among Cadets reveals that they prefer to select their own groups, in doing so, better academic performance and more positive, good group dynamic are realized. Most would believe that this would lead to better performance and promote a good group dynamic. Another alternative is to group students based on prior academic performance. Over three semesters, we compare the results of these two types of grouping techniques; allowing the Cadets to select their own partner, and grouping by prior academic performance. We will discuss the pros and cons thus far. (Received September 22, 2010)

1067-Z1-2052 **Jonathan A Cox*** (coxja@member.ams.org), Department of Mathematical Sciences, SUNY Fredonia, Fredonia, NY 14063. *Grand finale: The Basel Problem as a culminating objective in Calculus II.* Preliminary report.

The Basel Problem—finding the exact sum of the series $\sum_{k=1}^{\infty} \frac{1}{n^2}$—baffled mathematicians for decades until Euler solved it in 1735. He later gave an alternate proof consisting of several steps, "each of which falls well within the scope of a modern calculus course" according to Dunham. Indeed, every step in the proof utilizes standard techniques from Calculus II. Furthermore, the proof broadly draws from diverse portions of the course, including integration by parts, improper integrals, and integration of power series, so that it serves as an elegant example of how these different concepts can be brought together and used in harmony.

Calculus II students in my classes complete steps of the proof as "puzzle pieces" during the semester and then, as the final activity of the course, put the pieces together to obtain Euler's sum.

The approach of assigning puzzle pieces building through the semester toward an ultimate course goal is transportable to other courses. At its best, in engenders in students feelings of curiosity and mystery, as well as a sense that the course material has a definite direction and larger purpose. (Received September 22, 2010)

1067-Z1-2054 **Edmond Nadler*** (enadler@emich.edu), Mathematics Department, Eastern Michigan University, Ypsilanti, MI 48197, and **Tae-wan Kim**, **Min-jae Oh** and **Sung-ha Park**. *Singularity of Cubic Bézier Curves and Surfaces.*

Parametric cubic polynomial curves are useful in applications, being of relatively low dimension, and yet, flexible in their shape. To use these curves fully, one must completely understand the cases of singularity, i.e., where the speed of the parametric curves is zero.

Parametric polynomial tensor product surfaces are useful as well, and these are often most easily generated from a network of curves. For these surfaces, singularity occurs when the normal vector, defined as the cross product of the two partial derivatives, 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.

An industry application motivating the present work comes from computer-aided design of ship hulls. (Received September 22, 2010)

1067-Z1-2061 **Jim Fulmer*** (jrfulmer@ualr.edu), 2801 South University Ave, Little Rock, AR 72204-1099, and **Tom McMillan** (tcmcmillan@ualr.edu), 2801 South University Ave., Little Rock, AR 72204-1099. *What to Do on Day One in Calculus One.*

This talk will describe our opening day in Calculus I. We will briefly describe rate of change using the example of a new college graduate with two job offers in hand. Both jobs offer the same starting salary but with different opportunities for advancement. Using salary growth as a comparison, we introduce "Δ"-notation. Graphs will be used for explanations. This leads to the derivative. Also, we will describe the derivative of a product using a geometric explanation involving "proof without words." This talk will describe how we attempt to energize student interest in Calculus I on the opening day of class. (Received September 22, 2010)

1067-Z1-2063 **Rebecca C Metcalf*** (rmetcalf@bridgew.edu), Bridgewater State University, Department of Mathematics & Computer Science, 229 Hart Hall, Bridgewater, MA 02325. *Concept Maps: What are they and what can we learn from them about students' understanding of mathematics?*

Concept Maps are emerging as tools to assess students' understanding of concepts in many disciplines. This session will begin with a brief overview of concept maps and what they can say about students' understanding. Findings from research on the connections students make between the multiple representations of functions collected during interviews where participants were asked to construct concept maps will be discussed. Examples of students' work indicating understanding of quadratic functions from a Precalculus course will also be presented. (Received September 22, 2010)

1067-Z1-2071 **William J Heuett*** (wheuett@marymount.edu), Department of Mathematics, Marymount University, 2807 N Glebe Rd, Arlington, VA 22207, and **Bernard V Miller** and **Vipul Periwal**. *An Improved Model for Predicting Beta-Cell Insulin Secretion Rate from C-Peptide Data.*

In a clinical setting, it is important to be able to extract the pancreatic insulin-secretion rate (ISR) and quantify β-cell function from C-peptide measurements. Several models have been proposed in the literature, but some of these are sensitive to numerical interpolations. We present an improved two-compartment model. Using a smoothness norm, the model requires only a simple linear algebra calculation to yield an initial guess of the ISR. A cost function is defined in terms of the ISR's non-negativity and smoothness and its goodness-of-fit to the C-peptide data according to the two-compartment model. Finally a parallel-tempered Monte Carlo simulation is performed to predict the ISR and its associated statistics. We analyze the model's behavior for different time-discretization schemes.

This work was supported by the Intramural Research Program, NIDDK, NIH. (Received September 22, 2010)

1067-Z1-2074 **David M Slater*** (dms236@cornell.edu), Center For Applied Mathematics, Cornell University, 657 Rhodes Hall, Ithaca, NY 14853, and **Paul H Steen** (phs7@cornell.edu), 346 Olin Hall, Cornell University, Ithaca, 14853. *Detecting Symmetry in Coupled Droplet Oscillations.*

Symmetry detectives offer an automated method to classify the symmetries of solutions to dynamical systems – we shall illustrate on a coupled-droplet oscillator problem. This is achieved by mapping a trajectory into an appropriate representation space and detecting symmetry by computing distances to fixed point subspaces of subgroups. The primary application of detectives has been the determination of symmetries of attractors as well as the detection of symmetry-changing bifurcations. In contrast, we utilize symmetry detectives in our analysis of the trajectories of a fourth-order S_3 symmetric model of three coupled inviscid liquid droplets. Since there is no dissipation in the model, there are no asymptotically stable attractors. Hence, solutions away from equilibrium are the focus. In particular, we examine trajectories with no initial velocity. Results of the symmetry detective approach are contrasted to a computation of the largest Lyapunov exponent, which indicates whether dynamics are chaotic or quasiperiodic. Both methods can be applied to a grid of initial conditions in an automated fashion. Our results demonstrate a strong correlation between symmetries and nonlinear dynamics. (Received September 22, 2010)

1067-Z1-2077 **Julian M Buck*** (jbuck@fmarion.edu), 232 Waccamaw Avenue, Columbia, SC 29205. *Crossed Products of Certain Non-Simple Non-Commutative C*-Algebras.*

The study of crossed product C*-algebras arising from minimal homeomorphisms of compact metric spaces (that is, where the underlying algebra is commutative) has been a major area of success in the classification program for nuclear C*-algebras. The work of H. Lin, Q. Lin, and N.C. Phillips has demonstrated that such crossed products have tracial rank zero, and are thus classifiable, given sufficient assumptions about their K-theory. A recent paper of A. Toms and W. Winter proved that crossed products by minimal homeomorphisms are stable under tensoring with the Jiang-Su algebra.

In this talk we discuss the problem of studying crossed product of C*-algebras where the underlying algebra is the space of continuous functions from a compact metric space X into some abstract C*-algebra A. This algebra is neither simple nor commutative, so techniques from the commutative case must be adapted to this new setting in order to study the resulting crossed product. We consider the important question of whether the crossed product has a well-behaved order structure for its Cuntz semigroup, a key piece of classification data. (Received September 22, 2010)

1067-Z1-2081 **Jessica M Mikhaylov*** (jessica.mikhaylov@usma.edu), D/MATH, US Military Academy, 646 Swift Road, West Point, NY 10996, and **Nancy S Libertini**. *Designing a parenting seminar to address the national shortage of mathematicians.*

In response to the small numbers of American mathematicians, multiple programs have been rolled out to attract the next generation. There are programs that target students at all levels and give teachers additional training, all with the hopes of encouraging young minds to pursue the field of mathematics. However, many students' views of mathematics can be shaped or at least tainted by their experiences outside the classroom, particularly at home. It is our belief that parents can play an important role in their children's educational interests and pursuits. In order to harness the power of parents, we have developed a seminar designed to give non-mathematician parents a new appreciation for the field by allowing them to explore concepts ranging from non-Euclidean geometry to game theory using hands-on materials. The presentation will cover the purpose of the seminars, the outline and format of our seminar, and feedback from seminar participants. (Received September 22, 2010)

1067-Z1-2090 **Jennifer Franko Vasquez*** (frankoj2@scranton.edu), 800 Linden St, University of Scranton, Mathematics Department, Scranton, PA 18510, and **Steven T. Dougherty** (doughertys1@scranton.edu), 800 Linden St, The University of Scranton, Mathematics Department, Scranton, PA 18510. *Permutations and Ladders.*

Permutations are at the heart of abstract algebra and group theory. In this work we shall describe connections between Japanese ladders and permutations and then further extend this to the braid group. In this setting, the Feynman plate trick will naturally emerge as the key to understanding certain aspects of this connection. The foundation of this work is a visual representation of the permutation group using Japanese ladders. The fundamental results of permutations are described using techniques which will illuminate these often difficult to visualize properties. (Received September 22, 2010)

1067-Z1-2108 **Hollie L Buchanan*** (hbuchanan@westliberty.edu), 195 Campus Service Center, Box 295, West Liberty University, West Liberty, WV 26074. *Graph Factors Including or Excluding Certain Edge Sets in Bipartite Graphs.*

A necessary and sufficient condition is obtained for a bipartite graph to have an f-factor which includes a designated set of edges and is disjoint from another designated set of edges. Various other characterizations are obtained for similar subgraph structures and a characterization is obtained for a bipartite graph admitting an f-factor which includes no one of a collection of designated sets. (Received September 22, 2010)

1067-Z1-2113 **Rachel B Manspeaker*** (rbm001@math.ksu.edu), 126 Cardwell Hall, Manhattan, KS 66502. *Using Data-Mining to Classify Student Behaviors.* Preliminary report.

Often in a large lecture class like College Algebra, the greatest obstacle to providing personalized, effective education is the anonymity of the students. Data mining provides a method for describing students by making sense of the large amounts of information they generate. Instructors may then take advantage of this expedient analysis to adjust instruction to meet their students' needs. Using exam problem grades, attendance points, and homework scores from the first four weeks of a Studio College Algebra class, we were able to identify five distinct clusters of students: Overachievers, Underachievers, Employees, Rote Memorizers, and Sisyphian Strivers. During this talk we will discuss the methods used to find the clusters, how interviews further characterize the clusters' traits and behaviors, and the steps taken to modify placement and instruction. (Received September 22, 2010)

1067-Z1-2115 **Cathy W. Carter*** (ccarter@cbu.edu), 650 East Parkway South, Memphis, TN 38104, **Brittany Nicole Course** (bcourse@cbu.edu), 650 East Parkway South, Memphis, TN 38104, and **Alan Killen** (rkillen@cbu.edu), 650 East Parkway South, Memphis, TN 38104. *Folding Math Together - A Senior Seminar in Origami.*

The mathematics of origami is a fairly new and exciting field of study. It is based on seven axioms, known as Huzita's Axioms, which parallel the straight edge and compass constructions of geometry. This presentation describes some of the explorations of a senior seminar. We began by looking at simple examples of origami and investigated their relationships to previously encountered math. We found connections with optimization and tangent lines of calculus. Abstract algebra arose when we encountered extended fields. Graph theory abounded when we immediately thought of duals, Euler cycles, and bipartite graphs. Topics just covered in a complex analysis class reappeared in our origami study. We saw how something as simple as folding paper can actually be complex. We will engage the audience by guiding them through origami folds as we illustrate links to mathematics. (Received September 22, 2010)

1067-Z1-2117 **Itai Seggev*** (is+research@cs.hmc.edu), Wolfram Research, 100 Trade Center Ave, Champaign, IL 61821. *Using Mathematica to Teach Linear Differential Operators and the Method of Undetermined Coefficients.*

Viewing linear differential equations as in-homogeneous equations of linear differential operators provides theoretical insights, a nice connection to linear algebra, and a practical method for solving equations with simple (but important for applications) forcing functions. But let's face it, the algebra involved in applying the method of undetermined coefficients is a pain that increases rapidly with the order of the equations. In this talk, I present how to implement these differential operators in Mathematica and then use Mathematica to remove the grunt work from solving equations. This technique was employed in two different differential equations courses at Know College, a small liberal arts college in the midwest. Actual problems assigned to students will be included. (Received September 22, 2010)

1067-Z1-2122 **Heather A. Lewis*** (hlewis5@naz.edu). *Math Mistakes in the Media.* Preliminary report.
Two years ago at the Joint Mathematics Meetings I presented several real-life events in which mathematical errors had notable consequences. Math mistakes have continued to appear in news stories and advertisements, and this talk will focus on these more recent examples. (Received September 22, 2010)

1067-Z1-2123 **Andrew J Cousino***, Dept of Math, Cardwell Hall, Manhattan, KS 66502-2602. *Classifying Students by Conceptual Understanding in Real-Time.*

Is it possible to determine when students gain conceptual understanding during semester? I have built a real-time model of students' conceptual understanding in college algebra. It is updated after each assignment and exam and says whether each student is more likely to be learning than not based on grade of their work. A number of interesting questions arise from a model like this: can we tell when a student starts learning or stop learning, how quickly can we identify whether a student will almost certainly be one who learns throughout the semester, which assignments are better at classifying students, which assignments increase or decrease the number of students who are learning. The model is built using Bayesian learning, having been trained on college algebra students from last year, being tested on college algebra students from this year, and using Pre-calculus Conceptual Analysis exam (developed at Arizona State University by Marilyn Carlson, et al.) to initially classify students. (Received September 22, 2010)

1067-Z1-2143 **Alexander A Azzam*** (adamazzam@gmail.com), Lincoln, NE , and **Gizem Karaali** (gizem.karaali@pomona.edu), Claremont, CA. *Game Theory and School Choice.*

In graph theory, the stable matching problem is the problem of finding a stable matching in a bipartite graph. In this talk we examine a close variant of the stable matching problem known at the school choice problem. The school choice problem concerns the design and implementation of matching mechanisms that produce school assignments for students within a given public school district. Since school assignments are made given reported student preferences, this often incentivizes strategic reporting rather than truthful reporting. We then treat this variant of a classic problem as a cooperative private information game, and examine this problem from the perspective of game theory. We outline a coalitional strategy for the Gale-Shapley student optimal stable mechanism. If time permits, we will outline an adaptation of a well-known combinatorial optimization algorithm to the school choice problem, and discuss its relevant social interpretation and impact.

Part of this work was initiated/completed at the 2010 Claremont REU Program (Received September 22, 2010)

1067-Z1-2160 **Jinfeng Wei*** (jwei@maryville.edu), 650 Maryville University Dr., St. Louis, MO 63141. *Strategies of Involving Students in Teaching Calculus.*

My strategy to teach a complicated topic in calculus is separating it into several short topics. One of the biggest challenges in teaching calculus is how to make the hard topics easily understood. Using a visual description is my way to start a hard topic. (Received September 22, 2010)

1067-Z1-2163 **Yesem Kurt Peker*** (ykurt@randolphcollege.edu), Randolph College, 2500 Rivermont Ave, Lynchburg, VA 24503, **Catherine Beneteau** (cbeneteau@usf.edu), University of South Florida, Tampa, FL , and **David A. Eubanks** (deubanks@jcsu.edu), Johnson C. Smith University, Charlotte, NC. *RGB to HSI.* Preliminary report.

In this presentation we will share our work on the HSI (Hue,Saturation,Intensity) color coding scheme, in particular, the relation of it to the RGB (Red,Green,Blue) scheme and our understanding of what exactly hue, saturation, and intensity mean. We will demonstrate these meanings with programs written in the software Mathematica. The conversions from HSI to RGB and RGB to HSI spaces involve various topics in calculus, particularly in multivariable calculus, and can be used as a valuable teaching/learning tool in those courses. Also, understanding the HSI scheme is the first step toward using it in applications. It is a scheme that is used extensively in image processing along with other color coding schemes. (Received September 22, 2010)

1067-Z1-2166 **Rachel R Roe-Dale*** (rroedale@skidmore.edu), Department of Mathematics and Computer Sci., 815 North Broadway, Saratoga Springs, NY 12866, and **Michael O'Rourke**. *A Model for Damage to Buried Segmented Pipe.* Preliminary report.

The development of an analytical model to describe seismic damage to buried segmented pipe is presented. These pipelines provide valuable infrastructure, and the investigation into the effects of seismic activity on their integrity helps predict future incidences of failure. The model presented considers the effects of ground strain parallel to the pipe axis and its effects on the pipe joints. In the development of the model we consider various parameters including pipe segment length, burial depth, and soil properties. Our results provide an analytical relationship to predict the damage rate for various parameter combinations. We then compare these results with empirical observations (repairs per kilometer) collected from various earthquakes. (Received September 22, 2010)

1067-Z1-2167 **Dawn Archey*** (darchey@mmm.edu), 122 Ashland Place, Apt 15 D, Brooklyn, NY 11201. *Writing Projects For Mathematics Courses.*

I will discuss a few projects for lower level undergraduate courses which I have used successfully. For example, one project asked students to find and interview someone who used Taylor Polynomials professionally. (Received September 22, 2010)

1067-Z1-2178 **Jean W. Richard*** (jrichard@bmcc.cuny.edu), BMCC/CUNY- The City University of New York, Department of Mathematics, N524, New York, NY 10007, and **Abdramane Serme** (aserme@bmcc.cuny.edu), BMCC/CUNY- The City University of New York, Department of Mathematics, N770, New York, NY 10007. *The intellectual journey of Hua Loo-keng from China to the Institute of Advanced Studies.*

This talk is about the intellectual journey of Hua Loo-keng from Kunming University during the Sino-Japanese war, to the Institute of Advanced Studies at Princeton University in 1946. The talk explores the influence that the German mathematician Hermann Weyl (1885-1955) had on the self-taught Chinese mathematician Hua Loo-keng. Hermann Weyl and Hua Loo-keng were two of the twentieth century's most important mathematicians. Hua Loo-keng was a self-taught mathematician who left school at the age of fifteen and produced considerable work in number theory, algebra, geometry, and complex analysis. Hermann Weyl was a mathematician and philosopher with interests that ranged from foundations of mathematics to geometry, analysis, Riemann surfaces and was involved in the development of the theory of general relativity alongside Albert Einstein. While exploring the influence of Hermann Weyl on Hua Loo-keng, we will describe how, Hua Loo-keng created the movement of popularizing mathematics among the industrial workers and farmers in 1958 in the People's Republic of China. The Chinese industrial workers applied optimization methods extensively in solving industrial problems in almost all the Chinese provinces during the period of the movement of popularizing mathematics. (Received September 22, 2010)

1067-Z1-2187 **Thawda Aung*** (taung@randolphcollege.edu), Randolph College, 2500 Rivermont Ave, Lynchburg, VA 24503. *Cryptology with Mathematica.* Preliminary report.

In the Randolph College Summer Research Program 2010, I have worked on a project where I studied the mathematics behind cryptography. I also explored with the software Mathematica and implemented various cryptosystems and attacks against them. The implementations helped me to better understand the intricacies of secure communication. In this presentation, I will share my work from the summer research project and demonstrate how some cryptosystems work in practice using the programs I have written in Mathematica. (Received September 22, 2010)

1067-Z1-2195 **Mondal Sumona*** (smondal@clarkson.edu), 8 Clarkson Avenue, Potsdam, NY 13699, and **Bo Zhang**, **Kathleen R Fowler** and **Stefan Grimberg**. *Sensitivity Analysis of Anaerobic Digestion Model No.1 (ADM1) Using Latin Hypercube Sampling: A case study in dairy manure digestion.*

Anaerobic Digestion Model No.1 (ADM1) has been extensively used in modeling the Anaerobic Digestion (AD) process after its publication. Various biochemical kinetic parameters have been calibrated in different case studies to improve model accuracy. However, model calibration has been commonly empirically not following a logical mathematical process. In addition, biodegradability is considered to be the most important characteristic of feedstock; however, due to the absence of standard procedures in measuring the soluble inert and particulate inert concentrations, several methods have been devised by different researchers to estimate their concentrations. In order to facilitate the application of ADM1 in simulating dairy manure digestion, a method was developed earlier to calculate the soluble inert and particulate inert concentrations based on typical lab measurements with slight modification of the model by introducing two new stoichiometric parameters. The sensitivity of two newly introduced parameters, together with 32 biochemical kinetic parameters, were estimated using latin hypercube sampling based sensitivity analysis technique. (Received September 22, 2010)

1067-Z1-2197 **Ryan S Higginbottom*** (ryan.higginbottom@washjeff.edu). *From Zero to LaTeX in Three Weeks: Teaching Scientific Typesetting to Undergraduates.*

For the past two years, I have offered a class on Scientific Typesetting during my school's January term. I will discuss the content and methodology of the course along with some of the assignments my students completed. I will also explain what made the class significantly better the second time it was offered. (Received September 22, 2010)

1067-Z1-2200 **Dai Jialing*** (jdai@pacific.edu), 3601 Pacific ave, Stockton, CA 95211. *Paper Homework or Online Homework?* Preliminary report.

In this short talk, I would like to share my thought and concerns about the impact of different homework systems on student learning. At my institution, each professor has his/her homework policy. Some of us adopt online homework system, such as Webassign or Wiley Plus. I also have been using Webassign for Calculus, Probability, and Pre-calculus for a couple of years. While there are certainly some advantage of online homework, my colleagues and I also have been wondering how the online homework facilitate student learning. This semester, I am teaching two sections of precalculus, and I decide to conduct a very preliminary comparison study on online homework system and paper homework. I will share what I have found in the study. Hopefully this talk will generate further discussion on this topic and related issues. (Received September 22, 2010)

1067-Z1-2207 **Louis Deaett*** (deaett@math.uvic.ca), Dept of Mathematics and Statistics, University of Victoria, P.O. Box 3060 STN CSC, Victoria, BC V8W 3R4, Canada. *Vector coloring of graphs.*

Starting with a finite graph, we wish to 'color' each vertex with a vector from $\mathbb{C}^k$ in such a way that two vertices are adjacent if and only if the vectors assigned to them are not orthogonal. The salient question is: For a given graph, for how small a k is this possible? We will present some recent results on this problem and discuss its relationship with other problems in combinatorial matrix analysis. (Received September 22, 2010)

1067-Z1-2208 **Maria Neophytou*** (mneophyt@math.purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47907. *What is a Functional Equation?* Preliminary report.

A functional equation is an equation in terms of independent variables, and also unknown functions that are to be solved for; the derivatives of the unknown functions are usually not involved in the equation. Many properties of functions can be determined by studying the types of functional equations they satisfy, and functional equations play an important role in many areas of mathematics, from undergraduate algebra and trigonometry ($f(xy) = f(x) + f(y),\ f(x+y) = f(x)g(y) + g(x)f(y)$) to Number Theory (functional equation satisfied by the Riemann zeta function) and Complex Analysis (Schroeder's and Abel's equations).

Although finding all the solutions of a general functional equation can be quite challenging, some common solution techniques are known. For example, students in an undergraduate Real Analysis class can be asked to find the continuous solutions of Cauchy's equation, $f(x+y) = f(x) + f(y)$. We consider Schroeder's functional equation, $f \circ g = af$, where g is a given function and a is a constant. We discuss solutions f of this equation that map the unit disk into the complex plane and explain how to find solutions of the equation for some functions g. (Received September 22, 2010)

1067-Z1-2214 **John C Maceli*** (Maceli@Ithaca.edu), Mathematics Department, Williams Hall, Ithaca College, Ithaca, NY 14850. *Chebyshev Polynomials and their Relationship to Trigonometry and the Fibonacci Numbers.* Preliminary report.

This talk will illustrate the connections between Chebyshev Polynomials, Trigonometry and the Fibonacci Numbers(and the Lucas Numbers) . Using identities satisfied by the Chebyshev Polynomials we develop results from trigonometry and also Fibonacci identities. We show how to use a trigonometric identity (or Fibonacci identity) to find an identity for Chebyshev Polynomials. We will also show how these polynomials can be used in an "explorations" type mathematics course. (Received September 22, 2010)

1067-Z1-2236 **Bryan V Hearsey*** (hearsey@lvc.edu), 101 North College Avenue, Lebanon Valley College, Annville, PA 17003. *Fifty years of College Math. Have I learned anything?*

The Mathematical Sciences Department at Lebanon Valley College attract approximately 10% of the new students at the college each year and mathematical science graduates make up approximately 5% of a typical graduating class. This talk will consider some of the fundamental principles behind this success: Satisfied alumni are more important that satisfied students, Student interests trump faculty interests-successful species do not spend most of their time on reproduction, Learning to learn is goal one-students will not read a book that is read to them, Content is mostly irrelevant,Students will not work hard unless you do-pedogogy matters, you cannot do it alone-it takes a team. (Received September 22, 2010)

1067-Z1-2238 **Barbara P Gonzalez** (bgonzalez@roosevelt.edu), 430 S Michigan Ave, Chicago, IL 60605, and **Melanie A Pivarski*** (mpivarski@roosevelt.edu), 430 S Michigan Ave, Chicago, IL 60605. *Using Calculus to Model Aspects of the 2010 Gulf Oil Spill.* Preliminary report.

We will describe a series of short group projects themed on the 2010 gulf oil spill. In these group projects, we use data on the oil spill to motivate explorations of area, volumes, sums, and differential equations. This leads to discussions of why systematic processes are useful, what types of scientific information are needed to build a reasonable model, and the difference between experimental and computational sources of error. (Received September 22, 2010)

1067-Z1-2243 **Abigail L. Stevens*** (as656@bard.edu), 30 Campus Road, Annandale-on-Hudson, NY 12504, and **Gidon Eshel** (geshel@bard.edu). *Perfecting Solar Greenhouse Design for Hudson Valley Winter Agriculture.*

The motivation behind developing a feasible solar greenhouse is to grow food organically and sustainably near metropolitan areas in winter. This will extend the growing period, increase productivity, localize production and reduce transportation cost, and reduce greenhouse gas emissions to almost-carbon-neutral agricultural production. We created a matrix of the x-z cross section of the greenhouse, and used this to make a differentiation matrix to take the derivative of state vectors of the space. We plan to apply the differentiated state vector to the heat equation, to find the heated air flow inside the greenhouse. This will help us to optimize the thermodynamics of the solar greenhouse. (Received September 22, 2010)

1067-Z1-2245 **TseChing Lien*** (lien@math.wisc.edu), Department of Mathematics, 480 Lincoln Drive, Madison, WI 53715. *K-energy on hypersurfaces.*

In his 1994 paper, Tian provides a sufficient condition for a degree d hypersurface to be semistable in the sense of Mumford's geometric invariant theory. Specifically, he shows that when the Mabuchi energy functional on the space of Kahler potentials is bounded below, the hypersurface is semistable. In his proof, he introduces a (1,1) current on the space of degree d hypersurface. We provide an explicit bound on this (1,1) current in terms of the natural Fubini-Study form. (Received September 22, 2010)

1067-Z1-2248 **Xuhua Liu*** (xzl0002@auburn.edu), Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849-5310. *Multiplicities and generalized numerical range.*

We discuss the multiplicities of the relative interior points of the classical numerical range of an $n \times n$ complex matrix

$$W(A) = \{x^*Ax : x \in \mathbb{C}^n, x^*x = 1\}$$

and its generalization. Real analog is studied. (Received September 22, 2010)

1067-Z1-2249 **Charlie L. Smith*** (charlie.smith@park.edu), 8700 NW River Park Drive, CMB # 30, Parkville, MO 64152. *Fibonacci, Liber Abaci, and Medieval Mathematics.*

Due to a recent English translation, Liber Abaci is now available as a rich source of material for the history of mathematics classroom. Selected problems along with their solutions will be presented. A strategy will be suggested for incorporating Leonardo of Pisa into a math history course. (Received September 22, 2010)

1067-Z1-2253 **Lakshmi Roychowdhury*** (lakshmi@stat.tamu.edu), 416 Stasney Street, Apt 7, College Station, TX 77840. *Optimal points for a probability distribution on Cantor set.* Preliminary report.

It is well-known that the classical Cantor set C is generated by the two self-similar mappings S_1 and S_2 on $[0,1]$ given by $S_1(x) = \frac{1}{3}x$ and $S_2(x) = \frac{1}{3}x + \frac{2}{3}$. Let $P = \frac{1}{2}P \circ S_1^{-1} + \frac{1}{2}P \circ S_2^{-1}$. Then P is a probability measure on $[0,1]$ with the support C. Let X be a random variable taking values on $[0,1]$ with the probability distribution P. Note that X is a continuous random variable. If one wants to send the information about X to some other place by sending some discrete points say n points, in my talk I will show what are the n-best points for $n = 1, 2, \cdots$. Here by the 'best points' or 'optimal points' it is meant: the points for which the error is minimum with respect to some expect distance. (Received September 22, 2010)

1067-Z1-2254 **A Melissa Glass*** (cookma9@wfu.edu), 2933 Maggie Way, Boonville, NC 27011. *Fractals and their Dimensions.* Preliminary report.

Fractals are well known for thier interesting and beautiful pictures. But mathematically, fractals are known for their dimensions. First, we will define some well known examples. Next, we will discuss different notions of dimension. Then we will compute some dimensions for the well known fractal examples. (Received September 22, 2010)

1067-Z1-2255 **Robin Neumayer***, 1400 Greene St PO Box 83442, Columbia, SC 29225. *Asymptotic Connectivity of Hyperbolic Tilings.* Preliminary report.

Asymptotic connectivity is a measure of overall connectivity of infinite graphs, computed by finding the average connectivity of a ball centered at a basepoint and looking at the behavior of the connectivity in the limit. It is unclear in the general case if asymptotic connectivity is independent of the choice of basepoint. We will study infinite graphs comprising half-planes with d-regular hyperbolic tilings of f-gons for varying f and d. In particular, we will prove that the asymptotic connectivity of a graph G formed by joining arbitrarily many half-planes of regular hyperbolic tilings of varying degrees of varying f-gons is independent of basepoint. (Received September 22, 2010)

1067-Z1-2256 **James S Rolf*** (jimrolf@yahoo.com), 1333 Culebra Avenue, Colorado Springs, 80903. *CalcTool 3: An applet to visualize 3D objects.* Preliminary report.

CalcTool 3 is a freely available suite of Java applets designed to visualize three dimensional objects. I will demonstrate the basic functionality of these applets as well as illustrate how they can be used to help students discover and explore mathematical concepts in a multi-variable Calculus course. (Received September 22, 2010)

1067-Z1-2257 **Leslie M. Horton*** (lhorton@deltastate.edu), Delta State University, Department of Mathematics, Campus P.O. 3224, Cleveland, MS 38733. *Sugar Ditch Revisited.* Preliminary report.

In the 1980's Tunica, Mississippi was in the news – the poorest inhabitants of the poorest county in the nation were featured on such programs as "60 Minutes." In a an 1991 article published in the New York Times, Jason DeParle chronicles the movement of these individuals from the shacks erected on the banks of a sewage canal to modern apartments. With the influx of the casino business beginning in 1992, poverty in the area lessened. However, underachievement in the local schools persisted – until recently. Two teachers from a local elementary school attended an institute that opened their eyes to the possibilities of mathematics teaching that neither ever knew existed. The QDI in both classrooms improved dramatically. One of the teachers remarked: "I am a visual learner. I excelled in school and taught the way I was taught. I thought the problem was with my students – not with my teaching style." This talk will present data from the schools and chronicle the techniques that resulted in change in both students and their teachers. (Received September 22, 2010)

1067-Z1-2259 **Gary A. Olson*** (gary.olson@ucdenver.edu). *Pre-Service Teachers in the College Classroom-A Mentoring Experience.*

Six undergraduates pursuing secondary mathematics education licensure were recently chosen for participation in the Rocky Mountain Noyce Scholars Program. As part of their preparation to pursue mathematics teaching careers in high needs school districts, a college mentoring experience was implemented. The undergraduates were teamed up with a lead instructor and were designated as learning assistants for recitation sections associated with College Trigonometry. The development, implementation, and advantages of the experience will be discussed along with the positive impact the pre-service teachers had on the Trigonometry students' performance. (Received September 22, 2010)

1067-Z1-2265 **Liam Rafferty*** (raffertyl@mso.umt.edu), Liam Rafferty, Missoula, MT 59801. *Uniquely D-colorable Digraphs With Large Girth.* Preliminary report.

A classical result of Erdős is that for all integers k and g there exist graphs with chromatic number k and with girth at least g. Bollobás and Sauer strengthened this result by showing that there are such graphs which are, moreover, uniquely k-colorable. Colorings are special cases of homomorphisms into a fixed graph, and Zhu extended Bollobás and Sauer's result to homomorphisms into general graphs. Our work is to extend this result to digraphs with acyclic homomorphisms. (Received September 22, 2010)

1067-Z1-2293 **Yuyu Peng*** (yuyup@math.uci.edu), 3124 Verano Place, Irvine, CA 92617. *A Multiscale Gene Regulation Model: Mutual Inhibition Network in Epidermal Development.*

In biological systems, usually there are critical genes directly or indirectly control the differentiation and proliferation of cells. The population size is usually regulated by both cell secreted extra-cellular and intra-cellular molecules. Multiscale gene regulation models with single gene and double genes using hyperbolic PDEs are developed. By comparing the effects of periodic, single positive feedback and double negative feedbacks on maintaining stable cell populations and homeostasis of the system, we can show the important roles of gene regulation. We can demonstrate that robust size regulation can be achieved through a population level signal.s regulation. Hysteresis in the gene network, the balance between growth and differentiation in the cell populations are also investigated. The results hopefully can provide insight to the cause of uncontrolled proliferation and diseases including cancer. Combining with the experimental findings, we use the model to fill in the gaps of current biological knowledge and to provide an integrative view of the system. (Received September 22, 2010)

1067-Z1-2296 **Derek H Heilman*** (dhh26@drexel.edu), 3141 Chestnut Street, Philadelphia, PA 19104, and **Jennifer Morse** (morsej@math.drexel.edu), 3141 Chestnut Street, Philadelphia, PA 19104. *A new proof of the Pieri rule for the dual Grothendieck polynomials.*

The Robinson-Schensted-Knuth correspondence between bi-words and pairs of same shape Young tableaux has applications in various mathematical areas and in physics. A notable example is the proof of the Pieri rule which determines multiplication in the cohomology ring of Grassmannians. In the spirit of RSK, we provide a new proof of the Pieri rule for multiplying polynomials that are dual to the Grothendieck polynomials. (Received September 22, 2010)

1067-Z1-2298 **Emek Kose Can*** (eksecan@lmu.edu), 1 LMU Drive UHall 2700, Mathematics Department, Los Angeles, CA 90045. *Imaging Science For Undergraduate Projects Using ODEs and PDEs.*

Imaging science is a rapidly developing area of research in applied mathematics where there are many open problems involving elementary ideas from differential equations, geometry and numerical analysis. Catadioptric sensors are imaging devices that consist of cameras and mirrors. The main problem of catadioptric sensor design is to find a mirror surface so that the system images the world in a certain way. Different applications such as robot vision, surveillance or photography require different levels of mathematical backgrounds. The accessibility of catadioptric sensor design makes it ideal for undergraduate research projects. We discuss two such systems, one in which the goal is numerical solution of a nonlinear ODE. The other provides opportunity for discussing vector fields, integration of vector fields and numerical solution of quasi-linear PDEs. (Received September 22, 2010)

1067-Z1-2308 **Leonard J Lipkin*** (llipkin@unf.edu), Dept. of Mathematics and Statistics, University of North Florida, 1 UNF Drive, Jacksonville, FL 32224. *Let's Read the News.*

Some years ago, John Paulos wrote "A Mathematician Reads the Newspaper". Now there is news on the internet, TV, and newspapers 24/7. It is easy to pick out examples almost daily to teach students about flaws and misunderstandings in quantitative and logical reasoning. In this talk we give a variety of examples from several different branches of mathematics including voting, statistics, logic, and finance. (Received September 22, 2010)

1067-Z1-2314 **Justin Edward Sukiennik*** (jsukienn@umn.edu), 4 Vincent Hall, 206 Church St. SE, Minneapolis, MN 55455. *Height variations with change of variables.*

We will look at two strict, or "best possible", upper bounds for the differences in the height of a point and its affine linear image over a number field. From these results, we can demonstrate an asymmetry when we interchange the difference terms, which seems to run counter-intuitive to a result in a paper by C. Petsche, L. Szpiro, and T. Tucker. The proof the bounds are in fact strict follows mainly from Artin and Whaples Approximation Theorem. (Received September 22, 2010)

1067-Z1-2329 **Long Wang*** (lwang@spsu.edu), 1100 South Marietta PKY, Marietta, GA 30060, and **Kai Qian** (kqian@spsu.edu), 1100 Marietta PKY, Marietta, GA 30060. *Enhancing Student Learning in Calculus Through Subject-Oriented Projects.* Preliminary report.

Calculus as one of the core courses often becomes a hurdle for students majoring in computer science, engineering or sciences. One of the most likely reasons is that students do not understand why they need to take the course and how calculus is applied to their fields. Therefore they are not interested in learning the course. Moreover, the course is often taught using traditional methods, with lectures full of definitions, formulas and theorems, and homework followed by quizzes and exams, and as a result, students who are typically not engaged by the teaching method, fail to enjoy the beauty of calculus. We will develop a series of subject-oriented projects which present calculus related topics in the context of the students' major, as we believe that this will motivate students to learn calculus and improve their leaning efficiency. (Received September 22, 2010)

1067-Z1-2330 **Yun Lu*** (lu@kutztown.edu), Mathematics Department, Kutztown University of Pennsylvania, Kutztown, PA 19530. *Teaching Finite Mathematics Using Online Homework System.*

I teach finite mathematics regularly in Kutztown University of PA. This course focuses on the application of mathematical concepts and methods to problems that arise for students who major in Business or Computer Science. Recently, I taught a summer online course "finite mathematics" using MyMathLab, and in this talk I will share some of my experience with the audience along with students' feedback. (Received September 22, 2010)

1067-Z1-2331 **Mihaela Dobrescu*** (mihaela.dobrescu@cnu.edu), Newport News, VA 23606. *Cool Calculus; From Weight Loss to Climate Change in an Intermediate Calculus Course.*

A traditional intermediate calculus course deals with integration and its basic techniques, and concludes with sequences and series. An alternative approach to the final examination was considered. Students could choose a project on a topic on and beyond the concepts studied over the semester. They would use books and articles, they would write a research paper, and they would finish with a presentation. Many of these students went a step further with their presentation to regional undergraduate conferences, and some have submitted articles for publication. The alternative to the traditional final examination was beneficial to the students involved, to the rest of the class, to the department, and to the university. (Received September 22, 2010)

1067-Z1-2337 **J D Menges*** (jdmenges@aol.com), P.O. Box 3045, United States Military Academy, West Point, NY 10997. *Real Time Boundary Element Node Location Optimization.* Preliminary report.

The Complex Variable Boundary Element Method is an application of singular potential functions and includes other functions that are not singular but are fundamental solutions of the governing partial differential equation. These various singular potential functions form a basis whose span of linear combinations is a vector space that can be used to determine the closest element within to the exact solution of the PDE and related boundary conditions. Recently, work on the types of basis functions used in a BEM or CVBEM approximation has shown that considerable improvement in computational accuracy and efficiency can be achieved by optimizing the location of the singular basis functions with respect to both possible locations on the problem boundary and also locations exterior of the problem boundary. To develop such optimum locations for the modeling nodes, the approach presented in this work is to develop a Real Time Boundary Element Node Location module that enables the program user to click and drag nodes throughout the exterior of the problem domain. The provided module interfaces with the CVBEM program, built within program Mathematica, so that various types of information flows to the display module as the node is moved, in real time. (Received September 22, 2010)

1067-Z1-2351 **Robert Wieman*** (rwieman@vsu.edu), Department of Mathematics & Computer Science, P. O. Box 9068, Virginia State University, Petersburg, VA 23806. *Initial Assessment of an Enhanced College Algebra Course.* Preliminary report.

College Algebra is a problematic course at many universities, and Virginia State is no different. Our department has tried several directions, but passing rates have stubbornly remained below 50 percent each semester.

This Fall, we have introduced a weekly two-hour "Active Learning Environment" (ALE) session in addition to the three hours of lecture. The ALE session consists of a group activity, followed by individualized work in the form of self-paced computer exercises.

Approximately half of incoming freshmen in the School of Engineering, Science, and Technology were placed in Enhanced College Algebra with the ALE session (based on high school transcripts, SAT Math scores, and placement test results). The other incoming students were placed in conventional College Algebra sections. In this setting, we are able to assess the effect of our enhancements through several measures, including student affect and attitude as well as quantitative outcomes.

I present the results of this first semester, and the consequences of those results on our plans for the future of College Algebra at VSU. (Received September 22, 2010)

1067-Z1-2355 **Tevian Dray*** (tevian@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331, and **Corinne A. Manogue** (corinne@physics.oregonstate.edu), Department of Physics, Oregon State University, Corvallis, OR 97331. *Differences between Mathematicians and Physicists.*

Mathematics may be the universal language of science, but other scientists speak a different dialect. Mathematicians simply think differently from other scientists. There is nothing wrong with this, but the differences deserve explicit acknowledgment.

We report here on our very successful 15-year effort to bridge this cultural gap between lower-division mathematics and upper-division physics. To our own surprise, this gap is well described by the statement that lower-division mathematics is about algebra, whereas upper-division physics is about geometry. As evidenced by qualitative evaluation of student interviews, students who use our materials are more likely to reason geometrically than those who do not. Anecdotal evidence also suggests that these students perform at least as well on traditional questions, and do significantly better on conceptual questions. Our conclusion is that an emphasis on geometric reasoning, rather than algebraic manipulations, greatly enhances conceptual understanding. (Received September 22, 2010)

1067-Z1-2364 **Michael D. Bolt*** (mbolt@calvin.edu), 1740 Knollcrest Circle SE, Grand Rapids, MI 49546-4403, and **Daniel C. Isaksen**. *Dogs don't need calculus.*

Many optimization problems can be solved without requiring the use of calculus. By way of example, we describe a new variational method for optimization that relies on inequalities. The last example provides a completely algebraic solution to the problem of minimizing the time it takes a dog to retrieve a thrown ball. (Received September 22, 2010)

1067-Z1-2368 **Wei-Kai Lai*** (LaiW@mailbox.sc.edu), 807 Hampton Street, University of South Carolina, Salkehatchie, Division of Math and Science, Walterboro, SC 29488. *The Schur Property on Positive Tensor Products.* Preliminary report.

In 2008, Botelho and Rueda discussed the inheritance of Schur property from Banach spaces to their injective and projective tensor products. However, if considering positivity, the inheritance in the positive tensor products of Banach lattices may not be derived automatically from their work. In this talk, the technique and some new results of Schur property in the positive tensor products will be discussed. (Received September 22, 2010)

1067-Z1-2378 **James R. Valles Jr*** (james.valles@ttu.edu), TTU Mathematics, Math Bldg., Room 201, Box 41042, Lubbock, TX 79409-1042, and **Alexander Yu. Solynin** (alex.solynin@ttu.edu), TTU Mathematics, Math Bldg., Room 201, Box 41042, Lubbock, TX 79409-1042. *Affine Transformations and Conformal Invariants.* Preliminary report.

Affine transformations have been especially important in areas such as the Bôcher-Grace Theorem and Steiner inellipses and their effects on domains such as ellipses and regular polygons. Properties of domains, such as the conformal modulus of a domain in the complex plane, have been studied for their applications in fields such as Geometric Function Theory.

In this talk, the effect of affine transformations on conformal invariants of a domain will be explored. Of particular interest will be the application of affine transformations on quadrilaterals and conformal invariant properties of the quadrilateral under an affine transformation. (Received September 22, 2010)

1067-Z1-2401 **Adam Larios*** (adam.larios@gmail.com), 6502 Adobe Cir, Irvine, CA 92617, and **Edriss S Titi** (etiti@math.uci.edu), Dept. od Mathematics, University of California, Irvine, Irvine, CA 92697. *A Turbulence Model for Ideal Fluids: Analytical and Numerical Results.*

The equations which govern the motions of fluids are notoriously difficult to handle both mathematically and computationally. Recently, a new approach to these equations, known as the Voigt-regularization, has been investigated as both a numerical and analytical regularization for the 3D Navier-Stokes equations, the Euler equations, and related fluid models. This inviscid regularization is related to the alpha-models of turbulent flow; however, it overcomes many of the problems present in those models. I will discuss recent work on the Voigt-regularization, as well as a new criterion for the finite-time blow-up of the Euler equations based on their Voigt-regularization. Time permitting, I will discuss some numerical results, as well as applications of this technique to the Magnetohydrodynamic (MHD) equations and various equations of ocean dynamics. (Received September 23, 2010)

1067-Z1-2402 **Imre Tuba*** (ituba@mail.sdsu.edu), San Diego State University, Imperial Valley, 720 Heber Ave, Calexico, CA 92231, and **Jonathan Boiser** (jboiser@ucmerced.edu), School of Natural Sciences, University of California, Merced, 5200 North Lake Road, Merced, CA 95343. *Braid group cryptography and some related computational problems.*

In public key cryptography based on braid groups, A and B choose elements of the braid group B_n as their private and public keys, then use these to generate symmetric private keys for some sufficiently strong conventional cryptographic protocol. The protocol is secure if there is no computationally efficient algorithm to recover private keys from the public keys. The braid group is a group that is easy enough to describe, yet presents a number of computationally intensive challenges, such as the word and the conjugacy search problems, that can be exploited to construct key-exchange protocols that are difficult to attack. The security of such protocols depends on the difficulty of the related computational problems in the braid group, which are also of interest in their own right and are subjects of active research.

We introduce some braid-based key exchange protocols and the related computational problems. We discuss how hard these computations really may be, and present some of the ideas and algorithms that arose in the process of trying to find efficient solutions for them. We also give a brief overview of the current state of research. (Received September 23, 2010)

1067-Z1-2411 **Carl V Lutzer*** (cvlsma@rit.edu), School of Mathematical Sciences, RIT, Rochester, NY 14623. *The Alpha and the Omega of 1st Year Calculus.*

Most students complete their first year of calculus with Taylor Series. In this talk, I'll present a simple way to—crazy as it might sound—begin the year with Taylor expansions. I'll discuss the immediate payoff in the study of differential calculus, and touch on some of the long-term benefits that arise in integration theory and beyond. (Received September 23, 2010)

1067-Z1-2418 **Elizabeth C. Rogers*** (brogers@piedmont.edu), 135 Central Ave, Demorest, GA 30535, **A Poole James** (jpoole1122@lions.piedmont.edu), 1291 Taylors Drive, Watkinsville, GA 30677, and **Elizabeth L. Poole** (epoole1207@lions.piedmont.edu), 1291 Taylors Drive, Watkinsville, GA 30677. *Mental Mathematics as a Game: Historical Foundations Applied to Today's Classroom.*

This paper explores the development of mental mathematics systems and discusses their practical applications and use as educational games in the classroom. The four systems mentioned in this paper include the Vedic System, developed by the Aryans and the Trachtenberg System, created by Jakow Trachtenberg during World War II. Also, included are two Chinese contributions:the Abacus method and another from the book "The Nine Chapters on the Mathematical Art." The pros and cons of each method are discussed. Some of the techniques contained in this paper involve simple arithmetic sequences while others involve quadratic equations and matrices. (Received September 23, 2010)

1067-Z1-2428 **Smita Pati*** (spatimath@yahoo.com), Dept of Appl Math, Birla Institute of Technology, Mesra, Ranchi, 835215, India. *Periodic solutions of Some Ecological Models with Strong Allee Effects.*

In this article, we have obtained sufficient conditions for the existence of two positive periodic solutions for models representing dynamics of a renewable resource which is subjected to strong Allee effect. We have used Leggett-Williams multiple fixed point theorem to prove our results. (Received September 23, 2010)

SIGMAA RUME Session on Research on the Teaching and Learning of Undergraduate Mathematics

1067-Z5-60 **Michelle DeDeo*** (mdedeo@unf.edu), 1 UNF Dr., Dept. of Mathematics and Statistics, Jacksonville, FL 32259. *Improving Pass Rates in Mathematics using Interactive Software - Revisited.*

In 2001, my paper entitled Improving Pass Rates in Mathematics using Interactive Software was published in Selected Papers from the Twelfth National Conference on College Teaching and Learning which gave a positive assessment of the use of software as a component in the teaching of College Algebra. The paper supported the idea that interactive mathematics software promotes increased retention and success for students in College Algebra courses and those students were engaged in learning at school and at home.

In 2006 and in 2008, not only was this initial data confirmed, but one particular system proved to be more successful, more flexible and a better fit than the other systems that were tested. This talk updates those results and discusses the continued success.

We evaluate a total of nine years 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 taught without a software component. (Received July 06, 2010)

1067-Z5-343 **Eric D Weber*** (ericweber@asu.edu), 125 S Alma School Rd Apt 1065, Chandler, AZ 85224. *Reasoning about Functions of Two-Variables: A Case Study.*

I describe the results from a study investigating the conceptions and ways of thinking two second-semester calculus students developed during the course of a teaching experiment intended to foster powerful reasoning abilities about multivariable function. I reveal how two predominant means of thinking about function, shape thinking and axis thinking, supported and hindered students from developing a covariation view of two-variable functions. I discuss the importance of thinking about functions of one variable in a way that two-variable functions are coherent for both teacher and student. I conclude by discussing future directions of this line of inquiry, and discuss its necessity and importance for undergraduate mathematics education. (Received August 25, 2010)

1067-Z5-952 **Aaron Weinberg*** (aweinberg@ithaca.edu), Ithaca College, Mathematics Department, 953 Danby Rd, Ithaca, NY 14850. *Frameworks for Understanding Undergraduate Students' Conceptions of the Equals Sign.*

While many instructors may assume that their students have a good conception of equality, recent investigations on students' algebraic reasoning suggest that this may not be the case. This report examines the ways undergraduate students interpret expressions involving the equals sign and use the equals sign to represent situations involving comparisons. The study describes two perspectives that can be used to understand the ways students think about the equals sign: a semiotic perspective and a cognitive perspective. The presentation will discuss the benefits of each perspective along with their implications for instruction. (Received September 16, 2010)

1067-Z5-1007 **Nicholas Gorgievski*** (nick.gorgievski@nichols.edu), Nichols College, Center Road, Dudley, MA 01571, and **Thomas C DeFranco**, University of Connecticut, 249 Glenbrook Road, Storrs, CT 06269. *The Impact of the Spacing Effect and Overlearning on Student Performance in Calculus.*

In a Calculus course, homework problems can be assigned in various ways, through a massed distribution or through a cumulative distribution of problems. A massed distribution of homework problems is the traditional method of assigning problems which are blocked by type within a section. A cumulative distribution assigns problems from within a section and from previous sections. Research has shown that the cumulative assignment of mathematics homework problems can improve subsequent student test performance. Additionally, most mathematics textbooks rely on a format that emphasizes a common learning strategy called overlearning. By an overlearning strategy, a student masters a skill then continues to practice this skill. This learning strategy is common in mathematics since homework assignments tend to require students to solve many problems of the same type. This session will describe a study based on a quantitative research design that was employed in a large lecture Calculus I course at the university level to investigate the effects of massed versus cumulative practice and the overlearning strategy on student performance. Additionally, findings from the study and the implications for the teaching and learning of undergraduate mathematics will also be presented. (Received September 17, 2010)

1067-Z5-1084 **Jungeun Park*** (parkju20@msu.edu), 3305 East Lansing Dr. Apt 3d, Lansing, MI 48910, and **Sharon Senk** (senk@msu.edu), 333 North Kedzie, Michigan State Unversity, East Lansing, MI 48824. *University Calculus Instructors and Students' discourses on the derivative.* Preliminary report.

There are many studies about students' thinking about the derivative (e.g., Thompson, 1994; Zandieh, 2000). None, however, addressed how students use the terms, "derivative," "the derivative function," and "the derivative at a point" when describing those concepts and their relationships, or how instructors address them in the calculus class. This study, therefore, explores the main features of their discourses on the derivative in the classroom and interview settings with the data collected from student surveys (n=85), classroom observations (n=3), and interviews with students (n=12) and instructors (n=3). Analysis of students' discourses revealed their incorrect notions about the derivative, which are closely related to their use of the word, "derivative" without specifying it as the derivative function, $f'(x)$, or the derivative at a point, $f'(a)$, and descriptions of their relationship. Interestingly, the instructors also used the word, "derivative," without specifying its referent and implicitly addressed the relationship between $f'(x)$ and $f'(a)$ in the class. These results suggest that exact use of the terms and explicit discussion on the relationships would provide a better opportunity for students to learn the derivative. (Received September 18, 2010)

1067-Z5-1119 **Minsu Kim*** (minsu95@ou.edu), 6716 Lyrewood LN APT # 78, Oklahoma, OK 73132.
Differences in Beliefs and Teaching Practices between International and U.S. Domestic Mathematics Teaching Assistants. Preliminary report.

International mathematics teaching assistants (MTAs) and U.S. domestic MTAs are an indispensable part of mathematics departments regarding teaching a substantial portion of undergraduate students. Because MTAs' beliefs are significant roles for their teaching practices, this study examines the contrast between international and U.S. domestic MTAs' beliefs and teaching practices. This research aimed to answer the following questions: 1) What are the differences in beliefs and teaching practices between international and U.S. domestic MTAs? and 2) How are MTAs' different teaching practices shaped by their beliefs? The goals of this study help us understand the differences between international and U.S. domestic MTAs' beliefs and teaching practices. The results indicate significant differences in beliefs and teaching practices between the two groups centered on how they taught students to understand definitions and problems and how they motivated students to learn mathematics. The findings also described the relationship between MTAs' beliefs and teaching practices. (Received September 19, 2010)

1067-Z5-1245 **Sarah L. Marsh*** (sarah.marsh@ou.edu), Department of Mathematics, University of Oklahoma, 601 Elm Avenue, PHSC 423, Norman, OK 73019. *An Exploration of the Transition to Graduate School in Mathematics.* Preliminary report.

In recent years, much attention has been given to the new mathematics graduate student as a mathematics instructor. But, what other factors influence a student's transition into graduate school in mathematics? As students make the transition into graduate school in mathematics, they often face academic struggles, work to meet professors' and programs' expectations, and search for strategies to deal with this new chapter in their academic experience. This talk will present preliminary results and analysis from an interview-based qualitative study designed to explore these aspects of the transition to graduate school in mathematics. We will discuss some areas of the transition to graduate school arising from the data that may impact recruitment, retention, and protocols for graduate programs in mathematics. (Received September 20, 2010)

1067-Z5-1337 **Megan J Wawro*** (megan.wawro@gmail.com), 6475 Alvarado Road, Suite 206, San Diego, CA 92120-5013. *Individual and Collective Analysis of the Genesis of Student Reasoning regarding the Invertible Matrix Theorem in Linear Algebra.*

I present research regarding the development of mathematical meaning in an introductory linear algebra class. In order to analyze how students–both individually and collectively–reasoned about and with the Invertible Matrix Theorem (IMT) over time, I coordinate the analytical tools of adjacency matrices and Toulmin's (1969) model of argumentation at given instances in the semester as well as over time. Synthesis and elaboration of these analyses was facilitated by microgenetic and ontogenetic analyses (Saxe, 2002) and an approach for documenting classroom mathematics practices (Rasmussen & Stephan, 2008). Finally, a coordination of both the microgenetic and ontogenetic progressions illuminates the strengths and limitations of utilizing both analytical tools in parallel on the given data set. The data comes from video and transcript of whole class and small group discussion, as well as individual interviews with five students during a semester-long classroom teaching experiment (Cobb, 2000). Analysis reveals rich student reasoning about and with the IMT that may not be apparent through use of only one analytical tool. These and other results, as well as the methodological approach, will be discussed in the presentation. (Received September 20, 2010)

1067-Z5-1339 **Keith Weber*** (keith.weber@gse.rutgers.edu), Graduate School of Education, 10 Seminary Place, New Brunswick, NJ 08840. *Mathematics Majors' Evaluation of Mathematical Arguments and Their Conception of Proof.*

Twenty-eight mathematics majors were observed as they read and evaluated ten mathematical arguments. The results of this study suggest that: (a) mathematics majors do not hold empirical proof schemes, as is widely believed, but many are convinced by perceptual arguments, (b) they will often accept an argument as "mostly correct" and as a valid proof even if they do not understand a pivotal claim within the argument, and (c) many lack particular proof-reading skills needed to recognize the flaws in some arguments. (Received September 21, 2010)

1067-Z5-1357 **Kyeong Hah Roh** (khroh@math.asu.edu), School of Mathematical and Statistical Scienc, Arizona State University, P.O. Box 871804, Tempe, AZ 85287-1804, and **Aviva Halani*** (halani@mathpost.asu.edu), School of Mathematical and Statistical Scienc, Arizona State University, P.O. Box 871804, Tempe, AZ 85287-1804. *Enhancing Student Understanding of the Concept of Limit via Instructional Provocations.*

This presentation aims to address how instructional interventions may provoke college students to develop their reasoning and understanding in advanced mathematics. Two undergraduates from transition-to-proof courses participated in a teaching experiment for ten one-hour sessions in fall 2009. In this presentation, we focus on one of the sessions in which the research team engaged students in the $\varepsilon-$strip activity for the limit of a sequence. Data included videotapes of the session, copies of students' written work, and students' reports of interesting and challenging aspects of the session. In the data analysis, we traced changes in the students' criteria for and their reasoning about the convergence of a sequence as the instructional interventions were implemented. From our data analysis emerged contrasting prompts, pivotal-bridging examples, stimulating questions, and devil's advocate as effective instructional provocations. These provocations played a crucial role in developing students' reasoning and deepening their understanding of the concept of limit. We will discuss what types of, and to what extent, instructional moves would foster development of student reasoning. (Received September 20, 2010)

1067-Z5-1376 **John C Mayer*** (jcmayer@uab.edu), Department of Mathematics - CH 452, University of Alabama at Birmingham, Birmingham, AL 35294-1170, and **William O. Bond** (bondwil@uab.edu). *Blending Inquiry-Based Learning and Computer-Assisted Instruction in Algebra.*

In an experiment conducted in Fall Semester, 2010, we compare the effect of incorporating inquiry-based learning sessions versus traditional lecture sessions in a Basic Algebra course in which the primary pedagogy is computer-assisted instruction. Our research hypothesis is that inquiry-based learning sessions differentially benefit students in terms of mathematical content knowledge, problem-solving, and communications. In our experimental design, all students receive the same computer-assisted instruction component in a once-weekly meeting. For the two additional weekly class meetings, we divided the students randomly into three treatments: (1) two lecture meetings weekly, (2) one lecture meeting and one inquiry-based meeting weekly, or (3) two inquiry based meetings weekly. Measures, including pre- and post-tests, with an objective and rubric-scored parts, are described. Statistically significant differences between treatments have previously been observed in a similar study of multiple sections of a Finite Mathematics course in Fall, 2008, and a study of Basic Algebra with two treatments in Fall, 2009. (Received September 20, 2010)

1067-Z5-1438 **Elise Lockwood*** (elise314@gmail.com), 83 Kingsgate Rd., Lake Oswego, OR 97035. *Set-oriented Thinking and the Evaluation of Alternative Solutions in Counting Problems.* Preliminary report.

The literature indicates that students struggle with discrete enumeration problems, and there is thus a growing need to comprehend students' thinking as they count. Combinatorial texts vary between set- and process-oriented perspectives as they present counting methods. We investigate the implications of this dichotomy for combinatorics students, asking a fundamental question: How is the distinction between set- and process-oriented thinking relevant as post-secondary students solve counting problems? Eight students solved six counting problems and were then presented with alternative solutions. They were asked to make sense of the new solution, determine if it was different from their answer, and consider which was correct. The data was analyzed using grounded theory, allowing the researcher to develop themes that characterize student usage of each perspective. Analysis revealed that set-oriented thinking consistently emerged when students evaluated an error in a solution. A preliminary finding is that a set-oriented approach is a vital part of at least one aspect of counting: error detection and correction. Curricular implications might encourage teachers to incorporate both set- and process-oriented perspectives when introducing counting principles. (Received September 21, 2010)

1067-Z5-1451 **Tim P Fukawa-Connelly*** (tim.fc@unh.edu), Kingsbury Hall W348, Department of Mathematics and Statistics, University of New Hampshire, Durham, NH 03824. *Modeling Mathematical Behaviors; Making Sense of Traditional Teachers of Advanced Mathematics Courses Pedagogical Moves.*

This study investigates proof writing strategy within a traditionally taught abstract algebra classroom. Drawing on Rasmussen and Marrongelle's (2006) construct of Pedagogical Content Tools (PCTs) I expand the domain of analysis to include traditional instruction, and increase the number of PCTs under consideration. I describe how the instructor modeled behaviors that are important in learning advanced mathematics and characterize this a broad category of PCTs called Modeling Mathematical Behavior. Proof-writing was one of the most important of the classroom activities that I observed. During proof discussions, the instructor made significant use of questions, both directed at students and rhetorical. These questions, along with her statements, modeled strategies that students could use to help develop their proof-writing skills. While students were not observed to have adopted any of the modeled behaviors, I believe that these teaching techniques hold promise for changing instruction and improving student learning. (Received September 21, 2010)

1067-Z5-1677 **Kevin C. Moore*** (kvcmoore@uga.edu), Mathematics and Science Education, 105 Aderhold Hall, Athens, GA 30602-7124. *Quantitative Reasoning and Students' Approaches to Solving Novel Problems.*

This presentation reports on a series of investigations into precalculus students' reasoning when solving novel applied problems. Specifically, this report describes how a student's propensity to reason about quantities and relationships between quantities influences his or her problem solving behaviors. Students with a disposition towards identifying quantities (e.g., measurable attributes) in a problem situation constructed robust images of the problems' contexts. These orientation behaviors supported their using relationships between quantities to plan their solutions. The students were able to anticipate a series of calculations and provide a meaning for these calculations before performing any numerical calculations. In contrast, students who focused on procedures devoid of quantitative meaning were mostly unsuccessful in developing meaningful and correct solutions. These students predominantly executed numerical calculations step-by-step without planning future calculations. They also had difficulty providing a rationale for their solutions beyond referring to a previously learned procedure or formula. This presentation will provide an overview of these results, including insights into students' reasoning abilities that support their solving novel problems. (Received September 21, 2010)

1067-Z5-1727 **Stacey A. Bowling*** (staceybowling@me.com), 277 Palisades Drive, Morgantown, WV 26508. *Quantitative Reasoning and Student Understandings of Function Composition.*

Prior research on function composition has suggested that developing a robust understanding of function composition is critical in understanding subsequent topics in precalculus and calculus (e.g., related rates and trigonometric functions). However, little research has examined the mental actions and reasoning needed to understand and use function composition in ways that support understanding subsequent mathematical topics. The present study explored students' understandings of function composition in the setting of a precalculus class, using curriculum designed from theories of quantitative and covariational reasoning. This presentation highlights precalculus students' understandings of function composition relative to their quantitative reasoning abilities. Specifically, interview excerpts are presented that illustrate how students' ability to quantify problem situations and conceive of quantitative relationships and quantitative structures is reflected in students' understanding and use of function composition in novel problem settings. The students' actions emphasize the importance of students conceiving of a problem's context in ways that support mathematical reasoning (e.g., reasoning about the composition of functions). (Received September 21, 2010)

1067-Z5-1798 **Aron Samkoff*** (samkoff@gmail.com), Graduate School of Education, 10 Seminary Place, New Brunswick, NJ 08901, **Yvonne Lai** (yxl@umich.edu), 530 Church St., Department of Mathematics, University of Michigan, Ann Arbor, MI 48109, and **Keith Weber** (keith.weber@gse.rutgers.edu), Graduate School of Education, 10 Seminary Place, New Brunswick, NJ 08901. *How mathematicians use diagrams to construct proofs.*

Although some researchers argue that diagrams can aid undergraduates' proof constructions, most undergraduates have difficulty translating a visual argument into a formal one. The processes by which undergraduates can construct a proof based on a visual argument are poorly understood. We investigate this issue by presenting ten mathematicians with a mathematical task that invites the construction of a diagram and examine how they used this diagram to produce a formal proof. This talk focuses on (a) the extent to which mathematicians based their proofs on the diagram, (b) the ways in which they used the diagram, and (c) the skills and strategies they used to translate an intuitive argument into a formal one. We observed that mathematicians used diagrams to notice mathematical properties, to verify logical deductions, and, surprisingly, to justify assertions. However, their use of diagrams relied on sophisticated proving strategies and a range of logical skills, such as the ability to strategically reformulate logical statements. (Received September 21, 2010)

1067-Z5-2017 **George F. Sweeney*** (georgefsweeney@gmail.com). *Creating, Using and Interpreting Vectors and Vector Equation in a Classroom Community of Practice.*

One of the challenges of teaching linear algebra is fostering students' fluency with the symbolic and conceptual system of vectors and vector equations. Symbolizing vectors and vector equations is crucial as an entry point into the more theoretical and abstract world of linear algebra. In this study, six class episodes of a classroom teaching experiment (Cobb, 2000) were analyzed utilizing a modified Toulmin scheme (Rasmussen & Stephan, 2007) for the activities and practices involved with learning this conceptual system. I then triangulated this analysis with data from a series of focus group interviews and student work. This joint analysis focused on the creation, use and interpretation of vectors and vector equations as negotiated by members of the classroom. My presentation will provide an empirical analysis of what members of this classroom did and said in order to give insight into the questions: What do students think vectors and vector equations are? What does it mean for a set of vectors to span or be linearly dependent? What is a basis and why is it important? Answering these questions can aid instructional designers and teachers in expanding students' symbolic fluency and understanding of formalized linear algebra. (Received September 22, 2010)

1067-Z5-2194 **Mary D Shepherd*** (mary.shepherd@asu.edu), 333 E. Encanto Dr., Tempe, AZ 85281, and **Carla van de Sande**. *Reading Online Mathematics Textbooks, A Preliminary Study.* Preliminary report.

With traditional mathematics textbooks, students often complain about how hard it is to read their mathematics textbook. Teachers tell students to read an assignment either before or after coming to class, but most teachers are well aware that their students are not doing this. Many would agree that reading is critical for understanding, and that students will not reap the full benefits of the course if they ignore their reading assignments. There is not a large body of research on how students read their mathematics textbooks. It does appear that first year university students do not read mathematics textbooks well, even when they are good readers. Online mathematics textbooks and online learning are fairly recent (and increasingly popular) additions to what is available to students for learning material. Online texts can have interactive checks of comprehension and the inclusion of activities that foster reading strategies. There is virtually no research about how students read and interact with online mathematics textbooks. The emphasis of this study is to begin to understand how readers interact with an online mathematics textbook and study the effects of some online interactive activities that are intended to help students monitor their own comprehension as they read. (Received September 22, 2010)

SIGMAA on Enviromental Mathematics Contributed Paper Session

1067-Z8-2097 **John W. Day*** (johnday@lsu.edu), Dept. of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA 70803, and **Mathew Moerschbaecher**, Dept. of Oceanography and Coastal Sciences, School of Renewable Natural Resources, Louisiana State University, Baton Rouge, LA 70803. *The BP spill, peak oil, and the search for energy.*

The BP oil spill focused the world's attention on the impact of the spill on the northern Gulf of Mexico coastal ecosystems, especially the Mississippi delta, and the spill's socio-economic impacts. Almost all news reports have been on the impacts on the biota and the fate of the spilled oil. Almost never mentioned in the mainstream media is the larger energy context, especially that of peak oil, the time when world oil production will peak and decline irreversibly. Central to understanding the implications of peak oil is Energy Return On Investment (EROI - energy return on energy invested). Peak EROI was about 100:1 but it has declined to less than 20:1 for domestic oil. Recent analysis of ultra deepwater oil in the Gulf of Mexico suggests that the EROI is significantly less than 10:1. This suggests that this ultra deep oil will not be as significant to world oil supplies as was thought. And ultra deep oil, along with Arctic oil, is the last significant oil to be tapped. As energy gets more expensive, ecosystem services will become more important in sustaining the world's economy. The net natural asset value of ecosystem services of the Mississippi is between 350 billion 1.4 trillion dollars, more than the total worth of the remaining oil in the northern Gulf of Mexico. (Received September 22, 2010)

1067-Z8-2136 **James M. Hyman*** (mhyman@tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118. *The role of mathematics and modeling in cleaning up the BP oil spill.*

I will present examples of the role that the mathematical sciences are playing in understanding the impact of the oil spill and how mathematicians are helping in mitigating the damage. The mathematical analysis of the impact of the spill on the food web in the wetlands can help guide in the recovery efforts. During the spill, mathematical analysis gave the first reliable estimates of the flow rate from the plume and predicted the dispersal patterns for the oil. Mathematicians aren't physically cleaning up the oil spill, but they are helping those who are to do it better. (Received September 22, 2010)

1067-Z8-2281 **G. Paul Kemp*** (pkemp@audubon.org), National Audubon Society, Louisiana Coastal Initiative, 6160 Perkins Road, Suite 215, Baton Rouge, LA 70808. *Restoring Gulf Coast habitat after the BP oil spill.*

America's most biologically productive landscape is historically one of its most neglected. The Mississippi River delta and the Gulf are often on the losing end of some man-induced disaster, reminding us of the consequences of current mismanagement. We continue to ignore these warnings of our addiction to nonrenewable fuels. Myopia in environmental management has led to losses in ecosystem productivity and biodiversity, as well as losses in traditional economic terms, dollars and jobs. Oil came ashore at the beginning of nesting for many seabirds and turtles, crowded into ever diminishing barrier island habitat at the perimeter of the delta. Much coastal habitat oiled during the 100 days of the BP eruption was already significantly degraded by legacy effects of other oil & gas activities. The oil, detergent, and the intensive and intrusive cleanup operations caused visible damage to coastal habitats, and invisible damage offshore. Reported visible damage was in the form of wildlife body counts: 6050, 94, 591 for birds, mammals, sea turtles, resp. (USFWS, 22 Sept.) A very positive result was the amazing spontaneous response by volunteers to help make things right. National Audubon Society alone had upwards of 32,000 people register for training to work along the Gulf Coast. (Received September 22, 2010)

1067-Z8-2310 **Clint Dawson*** (clint@ices.utexas.edu), Institute for Computational, Engineering and Sciences, University of Texas, Austin, TX 78712. *Modeling Near-Shore and Coastal Processes and Extreme Events.*

We will discuss various modeling activities related to modeling near-shore and coastal processes. The research is motivated by studies of hurricane storm surges and the recent oil spill in the Gulf of Mexico. Topics to be discussed will include computational forecasting and hindcasting of storm surge, modeling of sediment transport, simulating flow through vegetative regions such as marshes and wetlands, and wave-current interaction. We will also discuss the coupling of hydrodynamics with particle tracking to model the Deepwater Horizon Oil Spill in near-shore environments (Received September 22, 2010)

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